

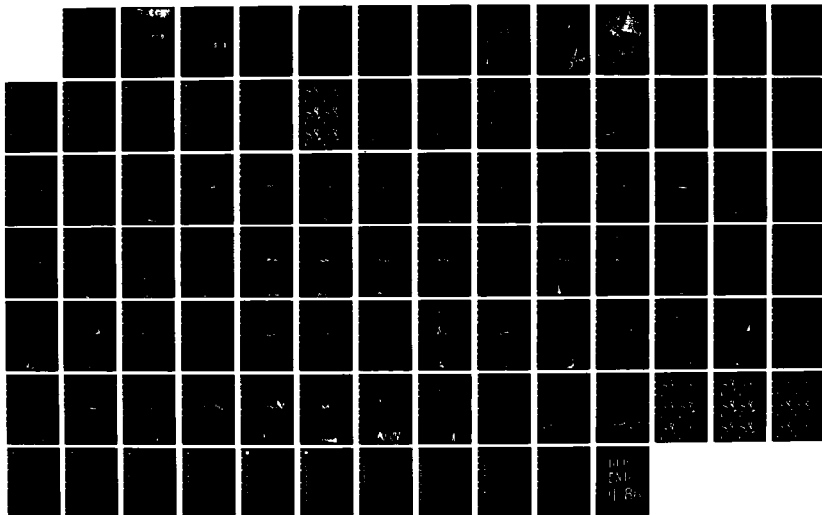
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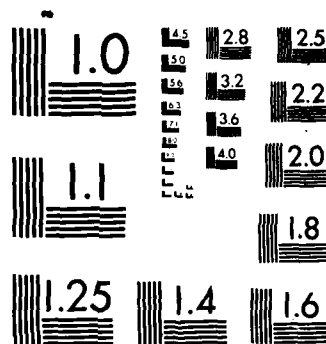
INVESTIGATIONS OF THE MICRO-TURBULENCE IN THE BOTTOM OF 1/1  
THE BOUNDARY LAYER(U) SCHMITT (RAINER) GLASHUTTEN  
(GERMANY F R) R SCHMITT 31 DEC 85 DAJA45-83-C-0038

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MICROCOPY RESOLUTION TEST CHART  
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Investigations of the Micro-Turbulence  
in the Bottom of the Boundary Layer

Final Technical Report

Dr. Rainer Schmitt

December 1985

DTIC  
ELECTE  
MAR 11 1986  
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United States Army

London England

CONTRACT NUMBER : DAJA 45-83-C-0038

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The data-format on the flex.disc is as documented in table No. 1:

Meteorology: DDD= Wind-direction (deg)  
VV.V=Wind-speed (m/sec)  
TT.T=Temperature ( centigrade) (attention: until ..  
35 deg.C must be subtracted from the indicated  
values  
FF.F=Wet-bulb-temperature (Centigrade)  
(attention:35.deg must be subtracted  
from the indicated values.)  
RR.R=Radiation-balance ( cal/scm/min)

C2n : Volts, Precision:0.01 Volt. maximum indicated value 9.99  
volts

Each measurement period is organized as one file, the maximum time  
for one measurement is 17 hours. Every file is organized as follows:

Record No. 1. Title, Location, Position (North, East), discription

Record No. 2. Empty

Record No. 3,4.Discription of data-records:

ST : Location Steinbach

yy : Year, Year: (84)

dd : Day , Day : (03)

hh : hour, hour (24 hour system , 17 = 5 pmm LST)

mm : minute,minute (20)

xyy : C2n-Values every 10 seconds, Volts (9.99)

Record No. 5 and following:

Data: Each Record contains 10 minutes of  
measurements with 20-second-single-  
values of C2n-signal and one set of  
10-minute-mean-values of meteorology.

As a basis for interpretation of the data we submit the following  
tables and figures:

The air-mass and the main weather situation according to Hess and  
Precowsky is given in table 3. The frequency distribution of the  
main weather conditions of the period 1931 to 1960 is presented in  
table 4., the figures 4 to 7 give typical examples of these main  
weather situations. The collection of tables gives the information  
of the air-mass and main weather situations for the months September  
1984 to October 1985. The air-mass for Karlsruhe is representa-  
tive for the location Steinbach, Bremen is representative for the  
location of Bremen (Publication of the German Weather Service).

TYPE CLASSIFICATION OF THIS PAGE (When Data Entered)

# REPORT DOCUMENTATION PAGE

## READ INSTRUCTIONS BEFORE COMPLETING FORM

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### 18. SUPPLEMENTARY NOTES

Refractive-Index-Structure-Parameter, micro-turbulence, atmospheric scintillation,

### 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Refractive-Index-Structure-Parameter, micro-turbulence, atmospheric scintillation, West-Germany, Boundary Layer

### 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Measurements of the microturbulence in the bottom of the atmospheric boundary layer using a two-ended scintillometer system have been performed at two sites in West Germany: more than 500 hours in a hilly area, 180 hours near the coast of the North-Sea. The data are presented as figures: signal as function of time.

The regional distribution of the climatic elements in Central Europe is presented in the maps of figure 8 ff..

The intensity of the two sources were set according to the distance source-receiver, using the curve of calibration setting in the instrument-handbook.

The data were collected using two Hewlett and Packard data-acquisition units (HP 3421) and two HP 71 computers. The linear output-signals of the scintillometers were monitored every 20 seconds, the data were stored in the internal memory of the computer. In Steinbach 10 min-mean values of the meteorological parameters: wind-direction, wind-speed, wet-bulb-temperature, temperature and radiation balance, were calculated.

The optical alignment of the system was controlled before starting the measurements and several times during the day. At Bremen the voltage-signal of the control-led was monitored to get an information of bad alignment or fog. It has been testet, that in case of fog the signal-value is constant, the voltage equals 0.34 volts.

From Steinbach the data were transferred to our laboratory via telephone-line using a software-controlled modem-system. The maximum uninterrupted measuring-time was 17 hours.

In this final technical report the data collected at Steinbach are presented in the figures at the end of the report. The scale of the Cn2-signal represents Volts (linear output of the instrument),

In the upper part of the pictures the meteorological conditions are documented: Temperature, humidity -as wet-bulb-temperature-, radiation-balance, and windspeed. From the indicated temperature-values 35 deg. Celsius must subtracted.

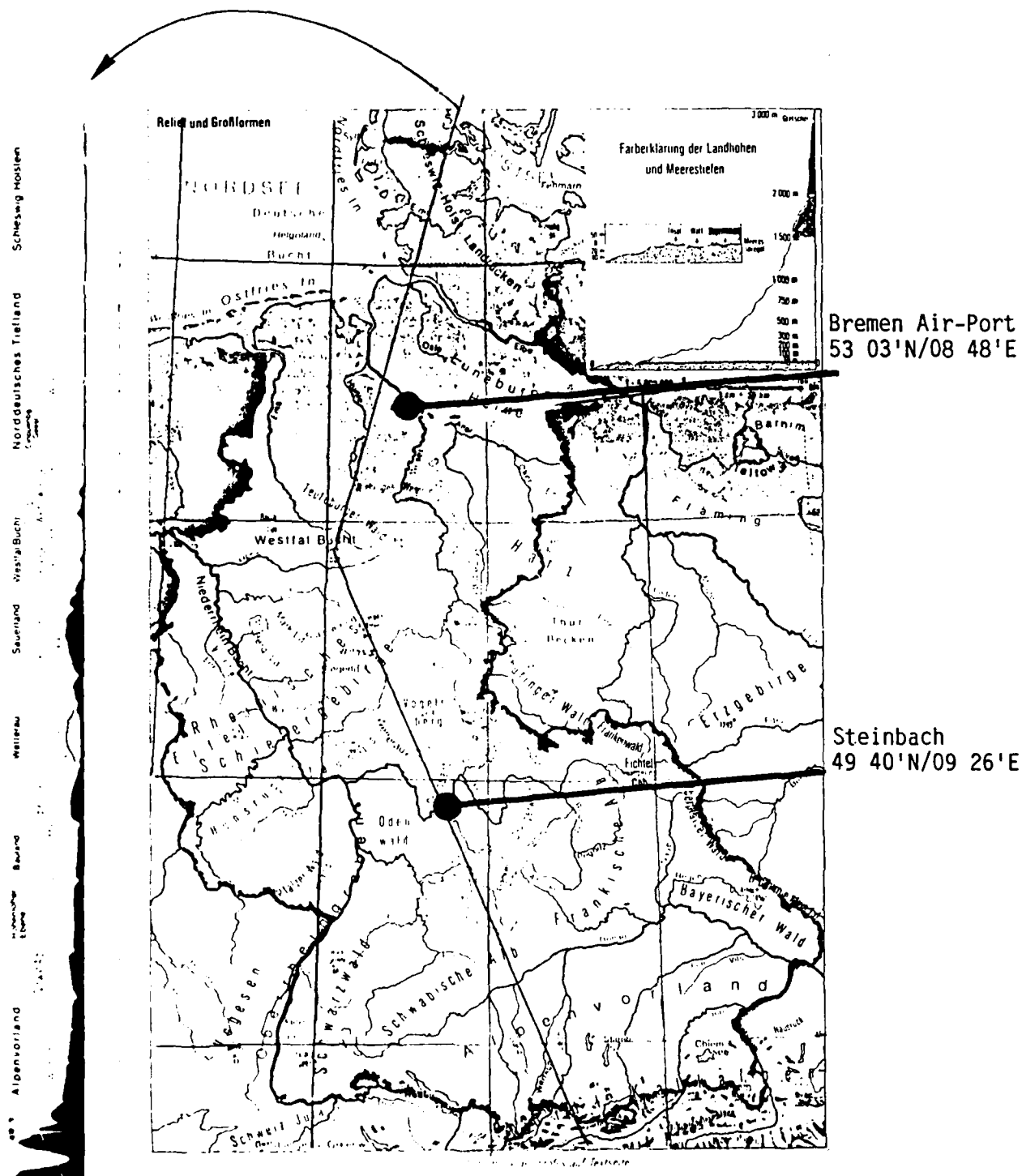
The data collected in the HP 71 have been transferred via a HP9845 desk-top computer to 8" HP formatted disketts and hereafter to IBM-4370 formatted 8"-ABCDIC-disketts. These diskettes were send to:

DEPARTMENT OF THE US ARMY ELECTRONICS RESEARCH  
AND DEVELOPMENT COMMAND  
US ARMY ATMOSPHERIC SCIENCE LABORATORY  
MR FRANK EATON /FCLAS/AF/D  
WHITE SANDS MISSILE RANGE, NEW MEXICO 88002

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DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	







Locations of measurements in West -Germany



▲ Steinbach  
49° 40' N / 09° 26' E



▲ Bremen Air-Port  
53 03'N/08 48'E

During the years 1984 and 1985 measurements of the micro turbulence in the bottom of the boundary layer were carried out at two sites in the Federal Republic of Germany.

The signal monitored corresponds to the refractive index structure parameter ( $C_n^2$ ) averaged over the path between a incoherent light source and a signal-receiver. The reported values are proportional to the logarithm of  $C_n^2$ .  $C_n^2$  can be calculated by applying the formular:  $C_n^2 = 10^{**(-14)} * \log^{**(-1)} \text{Signal}$  (Signal eq. Volts)

Figure 1 + 2 as marked on the maps, show the two locations in Germany. The details of the sites are shown in figure 2 (Steinbach) and 3 (Bremen); the scales of the maps are 1:50.000. Location 1 (Steinbach) is situated in a rural environment in a hilly terrain. The mean altitude is approximately 400 m MSL. The second location, Bremen, is in the northern Part of Germany, 100 km south east from the coast of the North-Sea. The site itself was at the airport of the city of Bremen.

To one of the copies of the report a coloured oro-hydrographic map (1:1.000.000) of the Federal Republic of Germany and two coloured maps of the area of the sites (1:50.000) are attached.

#### Maps:

Steinbach: Topographische Karte 1:50.000 No. L 6322

Bremen: Topographische Karte 1: 50.000 No. L 2918

Two auto-calibrating atmospheric scintillometers (Model IV-L) manufactured by Lockheed Engineering and Management Service Comp. Inc. were used. The instruments (sources and receivers) were mounted on aluminium-tower segments at a height of approximately 2 m to 2.5 m above ground. The distance between the source and the receiver was approx. 650 m at Bremen and 520 m at Steinbach. The surface was completely flat at Bremen, the systems were orientated horizontally. In Steinbach the surface between source and detector was flat within approx. 2 meters. The source was at a height of 415 m MSL, the receiver at 410 m MSL.

The surface at Bremen was covered with grass, at Steinbach rape was growing.

The system at Steinbach was orientated in north-south direction (source: south), at Bremen the orientation was west-east (source: east).

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# DIE GROSSWETTERLAGEN EUROPAS D 6170 E

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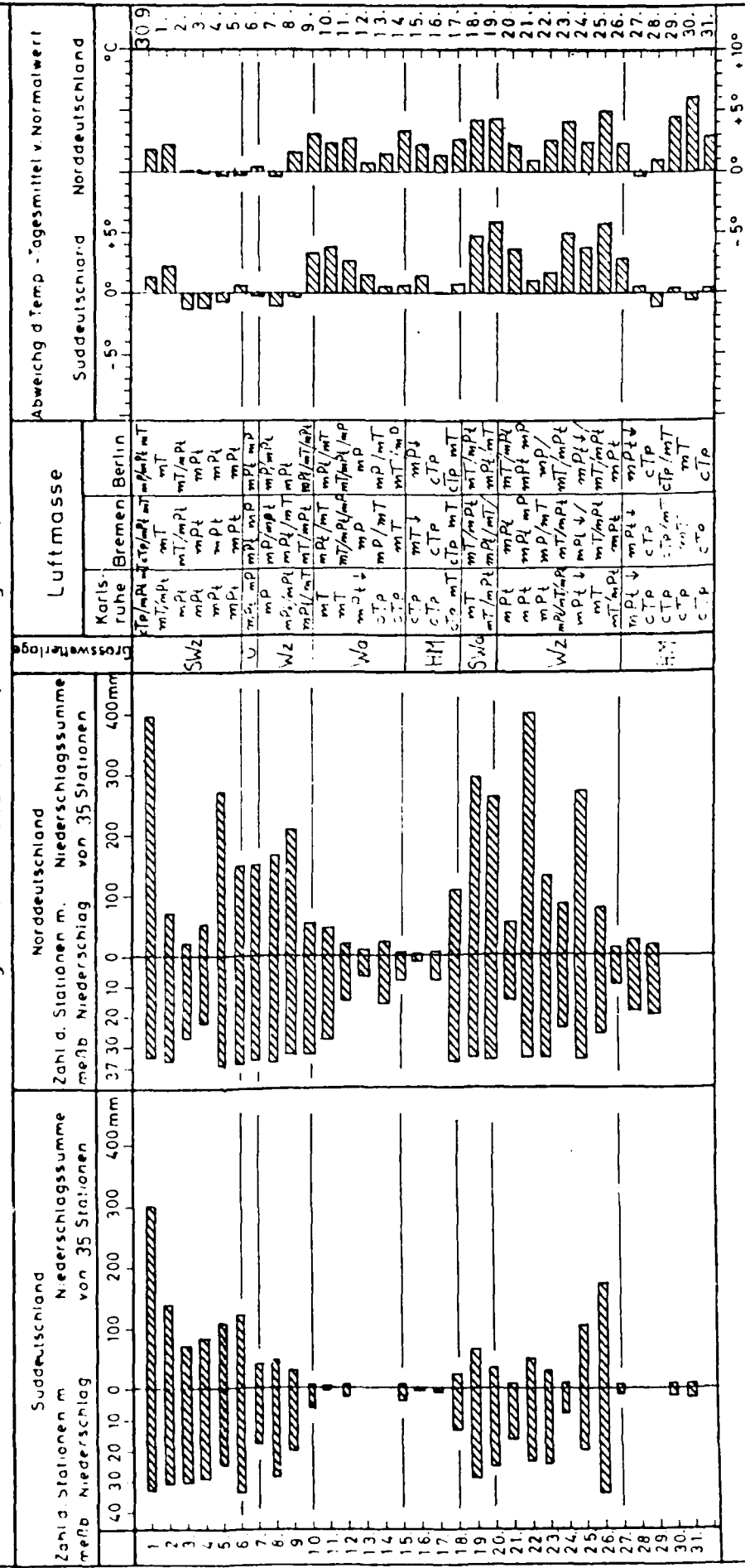
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37. Jahrgang

OKTOBER 1984

Nummer 10

## Witterungsverlauf in Deutschland (Bundesgebiet)



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38 Jahrgang

JANUAR 1985

# Nummer 1

Witterungsverlauf in Deutschland (Bundesgebiet)

Süddeutschland										Norddeutschland										Luftmasse			Abweichung d Temp. - Tagesmittel v. Normalwert																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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FEBRUAR 1985

## Nummer 2

### Witterungsverlauf in Deutschland (Bundesgebiet)

Suddeutsches Land										Norddeutsches Land										Luftmasse			Abweichung d Temp. - Tagesmittel v. Normalwerl																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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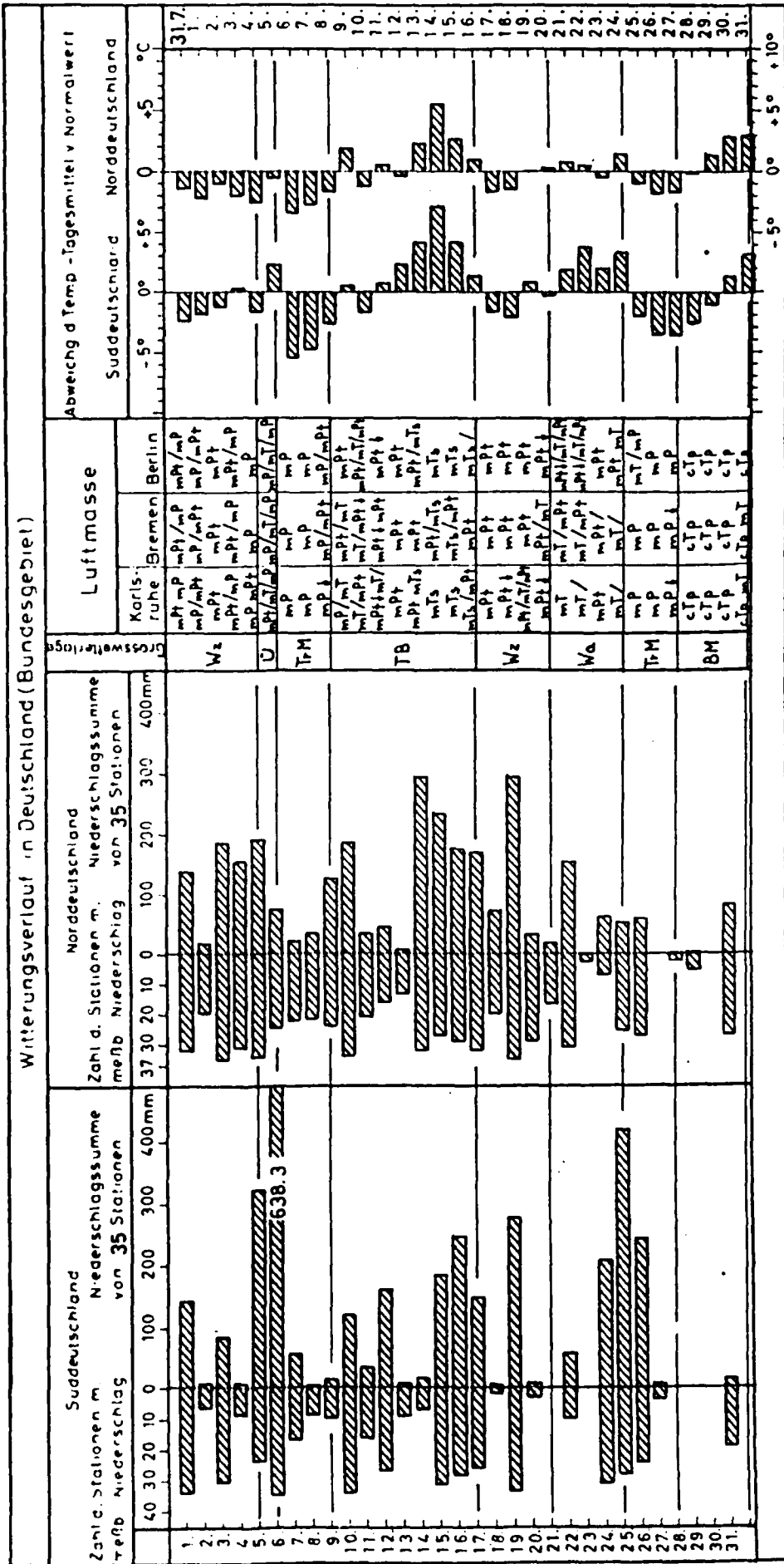
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Nummer 8



# DIE GROSSWETTERLAGEN EUROPAS D 6170 E

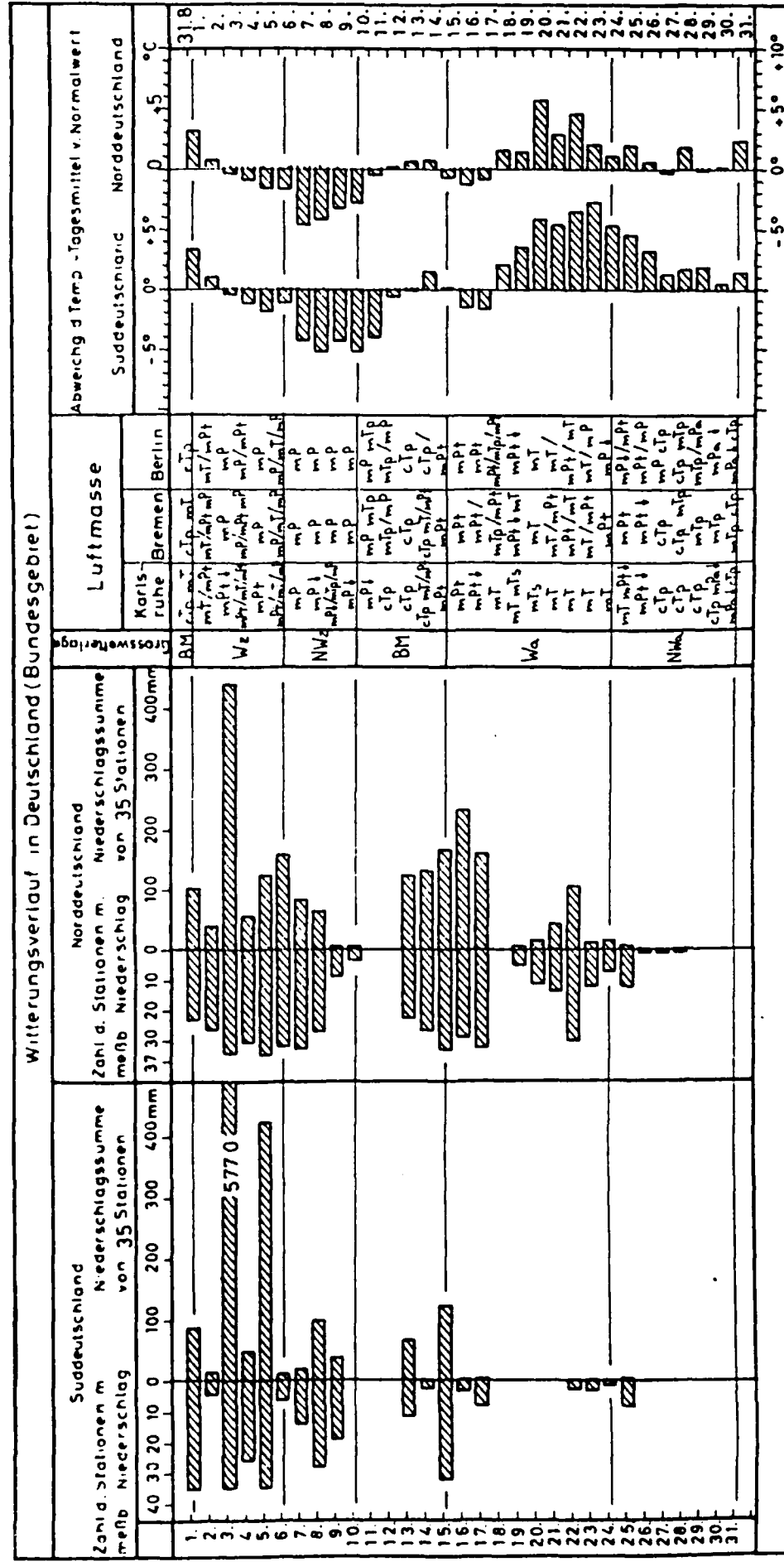
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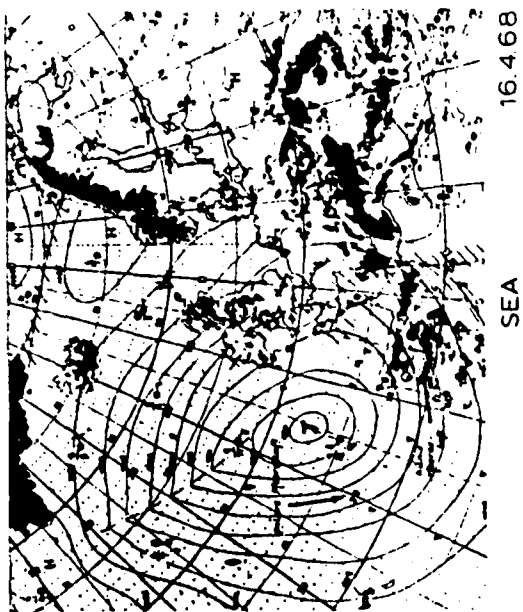


Relative Frequency Distribution of Main-Weather-Situations (GW) and Weather-Typs (GT) according to HESS/BREZOFISKY, as defined by the German Weather Service for the years 1881 to 1966.

The daily Main-Weather-Situation for the days of measurements are taken from "Die Grosswetterlagen Europas" published by the German Weather Service on a monthly basis.

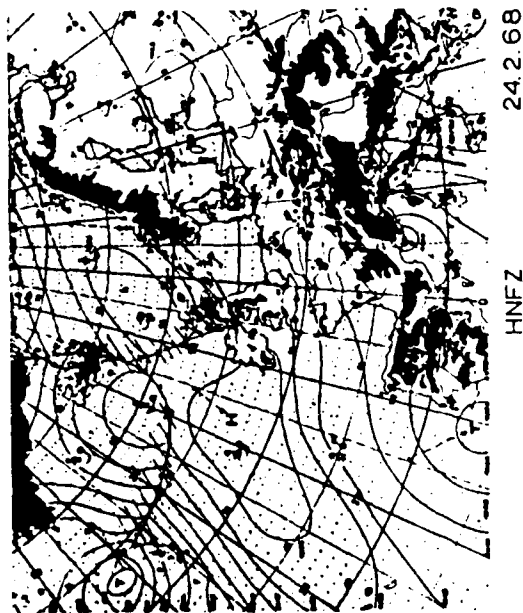
The Main-Weather-Situations are characterized by the attached typical weather maps.

GW-Lage	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Jahr	mittlere Streuung
WA	6.1	4.7	4.2	4.6	4.2	6.1	7.3	8.7	8.1	6.5	5.5	3.6	5.8	
WZ	13.5	12.3	11.4	11.7	12.2	15.7	19.9	23.5	15.1	14.7	13.7	17.9	15.2	
WS	4.3	5.8	6.1	2.6	0.7	1.8	1.8	2.1	1.0	3.4	3.4	6.8	3.3	
WW	3.4	1.4	3.3	2.1	1.1	2.1	1.2	2.9	2.4	2.1	4.5	5.1	2.6	
W (GT)	27.3	24.2	25.0	21.0	18.2	25.7	30.2	37.2	26.6	26.7	27.1	33.4	26.9	$\pm 1.8$
SWA	2.8	3.0	2.1	1.6	1.3	1.0	1.2	1.4	1.4	2.9	2.7	2.9	2.0	
SWZ	3.9	2.5	1.1	1.4	1.1	0.5	0.4	0.8	0.8	2.3	3.0	2.1	1.0	
SW (GT)	6.7	5.5	3.2	3.0	2.4	1.5	1.6	2.2	2.2	5.2	5.7	5.0	3.6	$\pm 1.6$
NWA	3.4	3.9	4.1	3.6	3.8	7.7	10.0	7.1	3.5	2.6	3.9	2.7	4.7	
NWZ	4.7	4.7	3.3	4.3	2.7	4.2	8.2	5.5	4.2	3.2	4.2	4.7	4.5	
NW (GT)	8.1	8.6	7.4	7.9	6.5	11.9	18.2	12.6	7.7	5.8	8.1	7.4	9.2	$\pm 1.7$
HM	14.5	13.7	11.3	6.6	9.4	9.7	10.8	10.0	16.0	12.5	7.8	10.1	11.0	
BM	4.1	4.8	3.5	5.5	3.6	4.8	5.1	6.9	7.5	7.6	9.8	9.3	6.0	
HM (GT)	18.6	18.5	14.8	12.1	13.0	14.5	15.9	16.8	23.5	20.1	17.6	19.4	17.0	$\pm 1.0$
TM	3.2	2.6	3.5	3.9	3.8	2.1	2.7	1.5	1.7	2.3	3.2	1.5	2.7	$\pm 0.5$
gemischte Zirkulation	36.6	35.2	28.9	26.9	25.7	30.0	38.4	33.1	35.1	33.4	34.6	33.2	32.5	
NA	0.3	0.4	1.2	1.0	2.7	2.6	1.7	1.3	1.0	0.3	0.6	0.7	1.1	
NZ	2.3	2.1	3.7	4.1	5.7	5.5	2.4	1.8	2.9	2.0	1.6	1.2	2.9	
HNA	2.3	2.1	2.8	5.7	6.5	6.9	3.3	3.1	3.8	3.4	2.1	2.3	3.7	
HNZ	1.2	1.4	1.8	1.8	2.3	1.9	0.9	0.8	0.4	2.1	0.9	0.9	1.4	
HB	2.8	4.5	3.8	3.3	3.9	4.3	2.0	2.5	4.6	3.3	2.6	2.1	3.3	
TRM	3.5	4.4	4.1	5.4	3.6	2.9	3.8	2.6	4.4	3.7	5.5	3.3	3.9	
N (GT)	12.4	14.9	17.4	21.3	24.7	24.1	14.1	12.1	17.1	14.8	13.3	10.5	16.3	$\pm 0.7$
NEA	1.7	2.5	2.9	2.6	4.8	5.1	4.5	3.0	2.4	1.1	0.8	1.1	2.7	
NEZ	2.0	1.7	2.3	4.4	3.5	3.1	2.4	2.1	2.6	1.6	0.6	1.8	2.3	
HFA	6.1	5.1	3.9	4.4	3.5	2.2	1.9	2.4	3.8	4.6	2.8	4.2	3.7	
HFZ	1.0	1.1	1.2	1.0	0.5	0.5	0.2	0.3	0.4	0.8	1.2	1.2	0.8	
HNFA	1.1	1.8	0.7	1.8	4.2	1.9	0.3	0.2	0.9	0.9	0.7	0.5	1.2	
HNFZ	1.1	1.8	3.9	2.8	3.3	0.8	0.7	0.8	0.6	0.6	1.5	0.6	1.5	
SEA	1.4	1.4	3.8	2.6	2.8	0.9	0	0.1	2.2	4.2	3.6	2.9	2.2	
SEZ	3.6	3.1	2.9	2.5	0.7	0	0	0.1	0.9	1.4	1.7	1.7	1.5	
E (GT)	18.0	18.5	21.6	22.1	23.3	14.5	10.0	9.0	13.8	15.2	12.0	14.0	15.9	$\pm 1.3$
SA	3.3	1.5	2.7	1.8	1.0	0.1	0.2	0.3	2.8	2.9	5.0	2.5	2.0	
SZ	0.6	2.3	1.0	0.7	0	0	0	0	0.3	1.2	2.0	2.4	0.9	
TB	0.8	1.7	1.0	2.6	3.5	1.7	2.8	4.3	1.1	2.1	1.9	2.1	2.1	
TRW	1.1	1.5	1.8	2.8	2.8	2.4	3.8	3.7	2.7	3.2	2.9	1.8	2.5	
S (GT)	5.8	7.0	6.5	7.9	7.3	4.2	6.8	8.3	6.9	9.4	11.8	8.8	7.5	$\pm 1.4$
meridionale Zirkulation	36.2	40.4	45.5	51.3	55.3	42.8	30.9	29.4	37.8	39.4	38.0	33.3	39.7	
U	0	0.2	0.6	0.8	0.7	1.5	0.5	0.3	0.5	0.5	0.3	0	0.9	



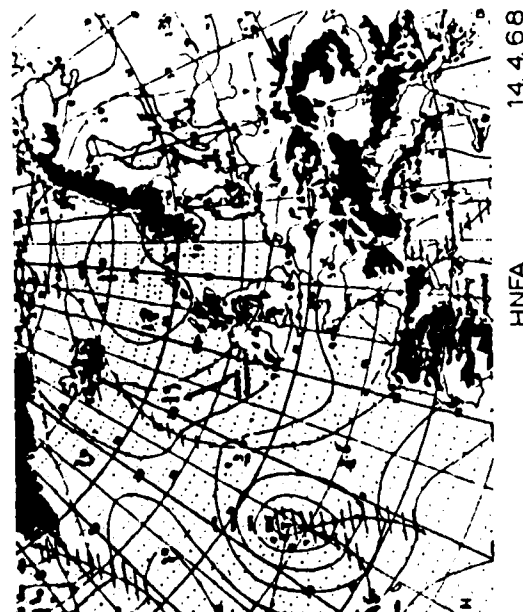
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16.4.68



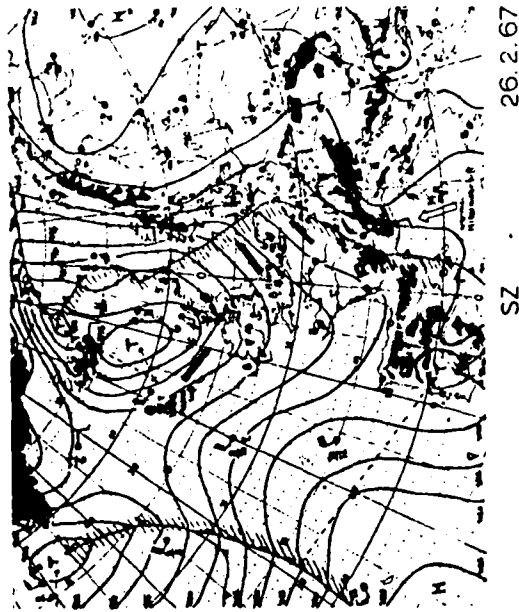
HNFZ

24.2.68



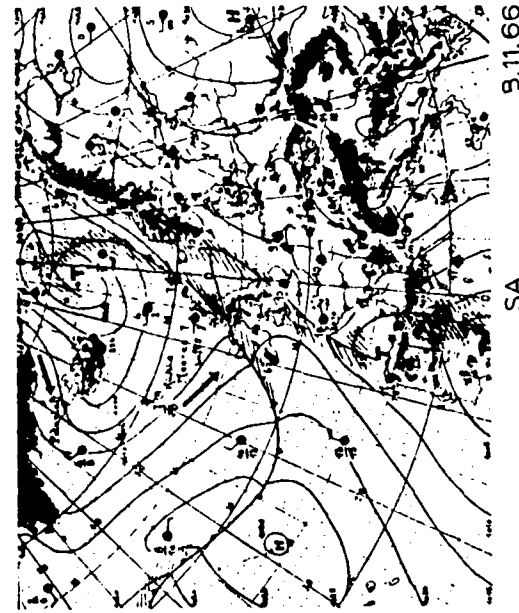
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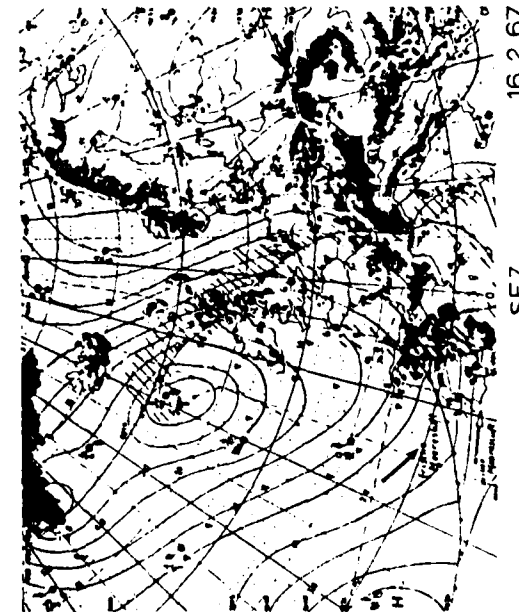
SZ

26.2.67



SA

9.11.66



SEZ

16.2.67

6 Typical Examples of European Main-Weather-Typs

Mean duration (days) of the frost-free period 1931-1960

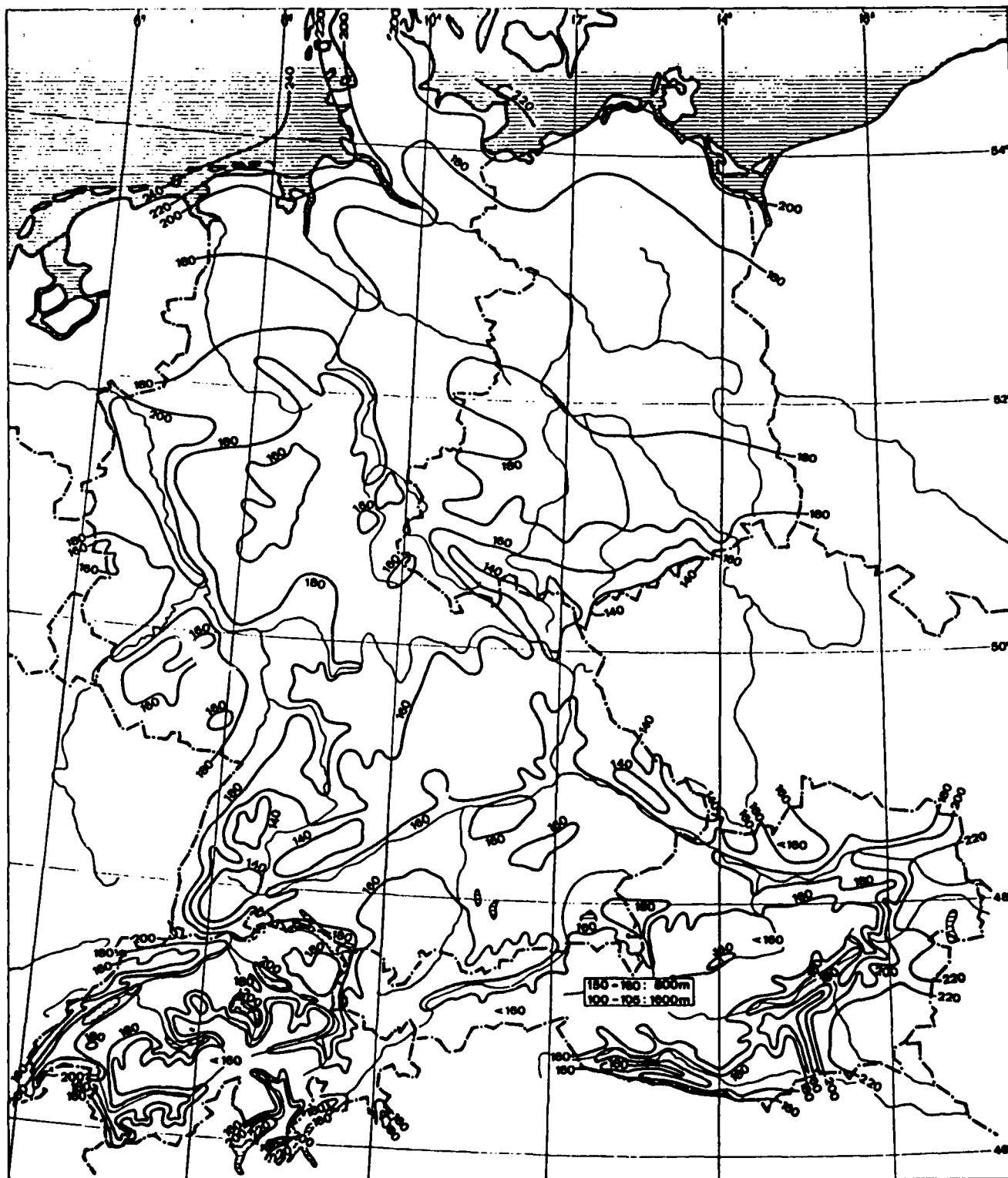


Fig.21. Mean duration (days) of the frost-free period 1931-1960.

Mean diurnal temperature variations in Celsius in January (1931-1960)

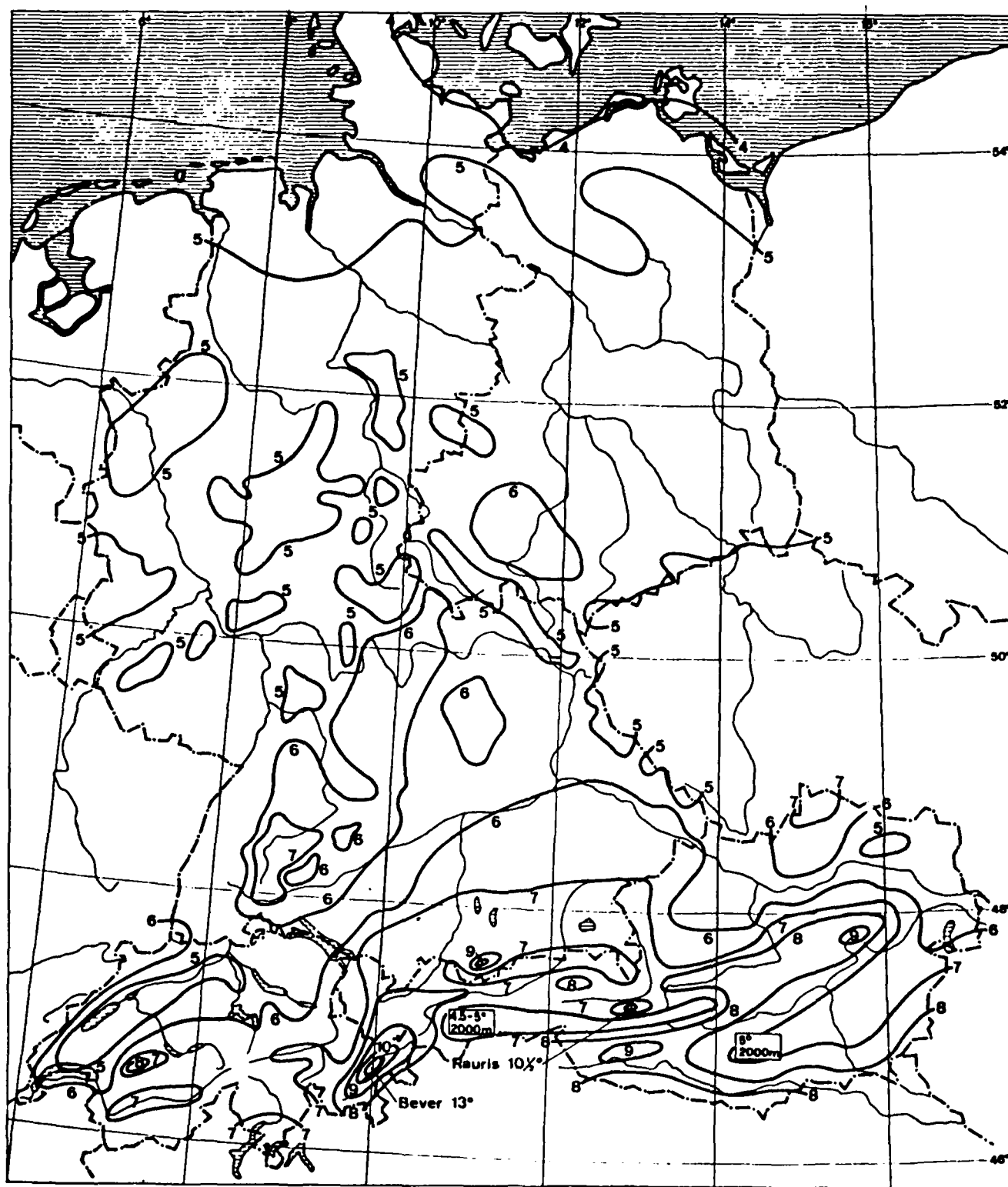


Fig.19. Mean diurnal temperature variation (°C) in January, 1931 -1960.

Mean diurnal temperature variations in Celsius in July (1931-1960)

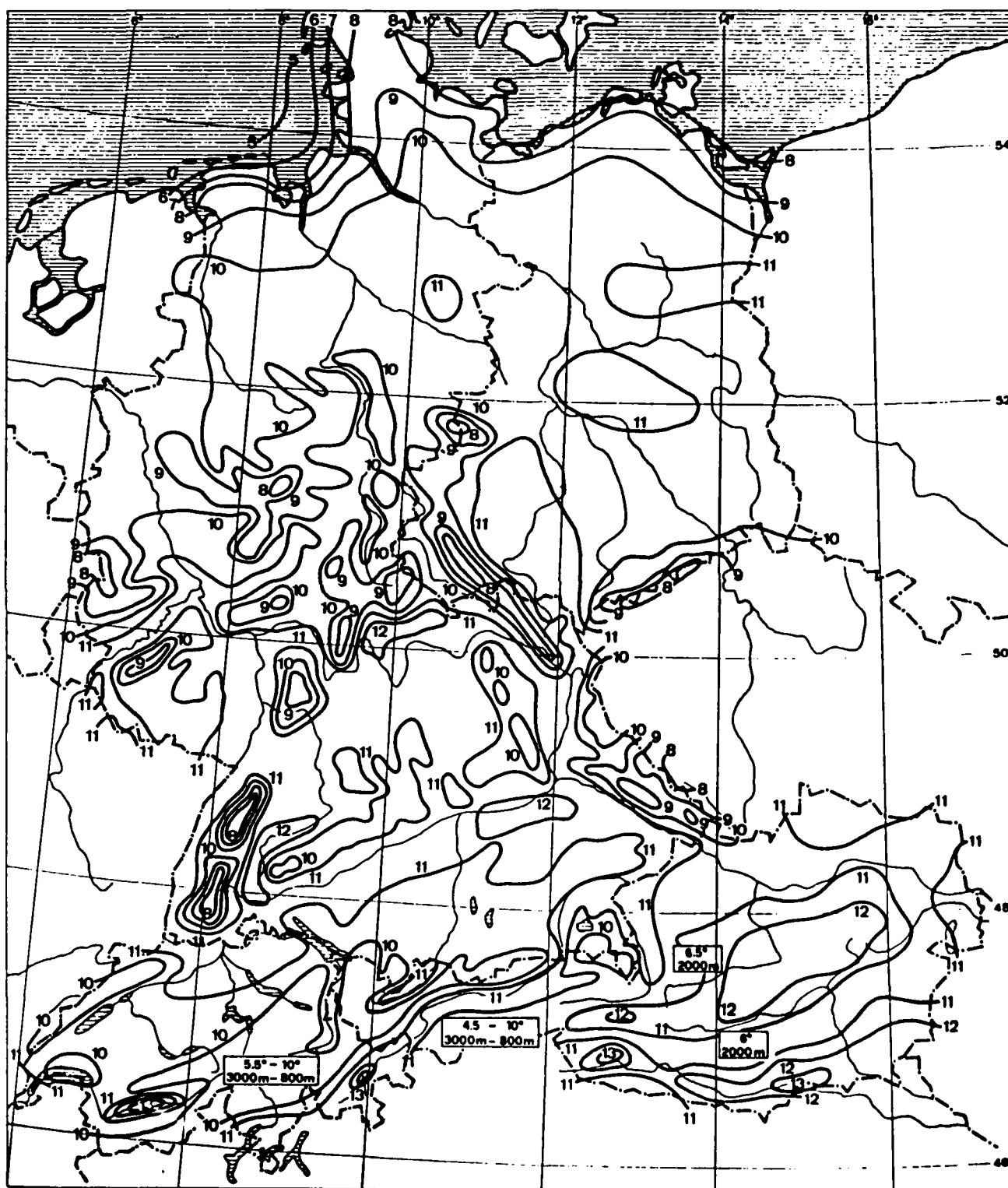


Fig.20. Mean diurnal temperature variation (°C) in July, 1931-1960.

Mean annual duration of sunshine (h) 1931-1960

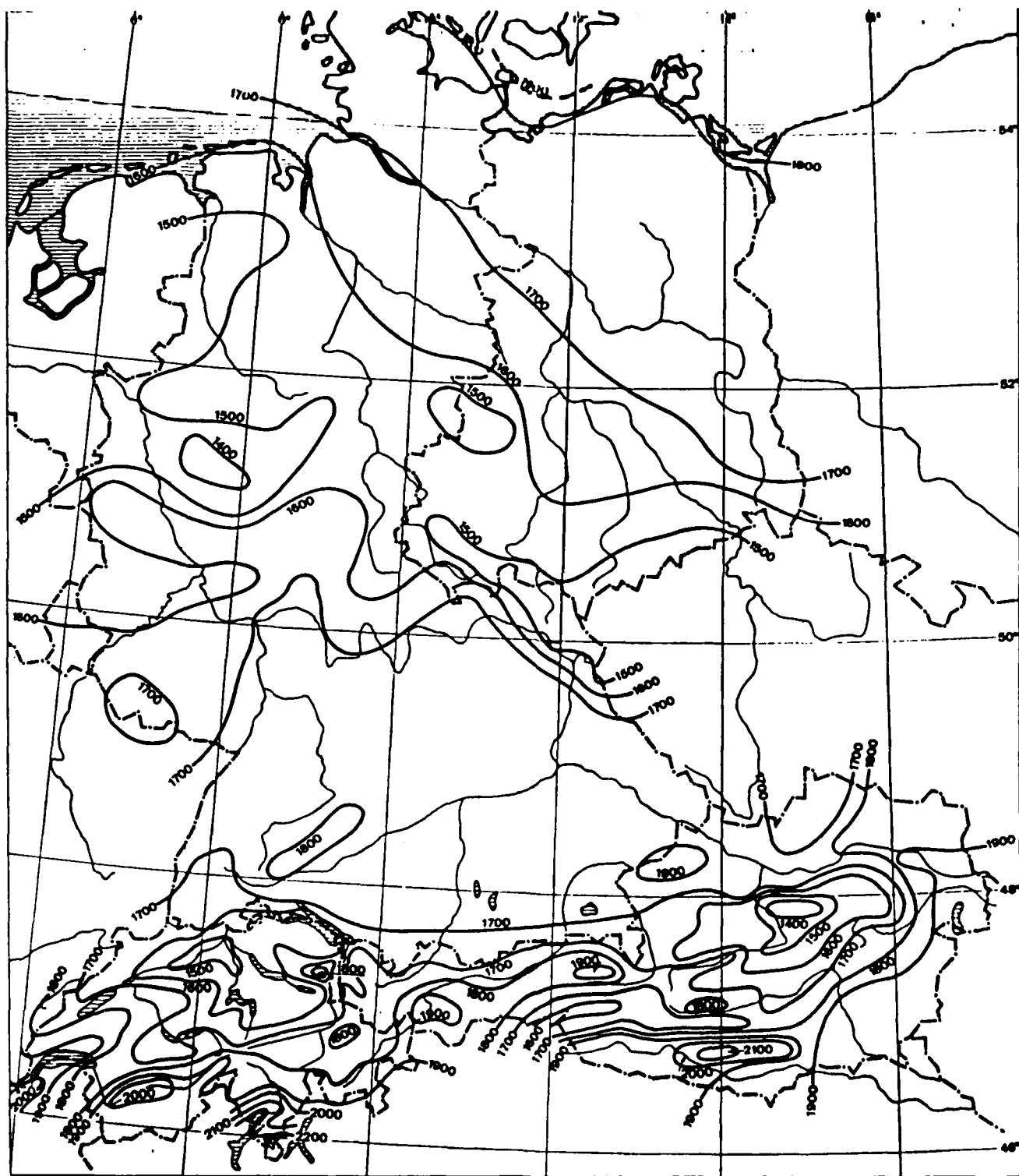


Fig.23. Mean annual duration of sunshine (h), 1931-1960.



Mean annual precipitation (decimeters) 1931-1960

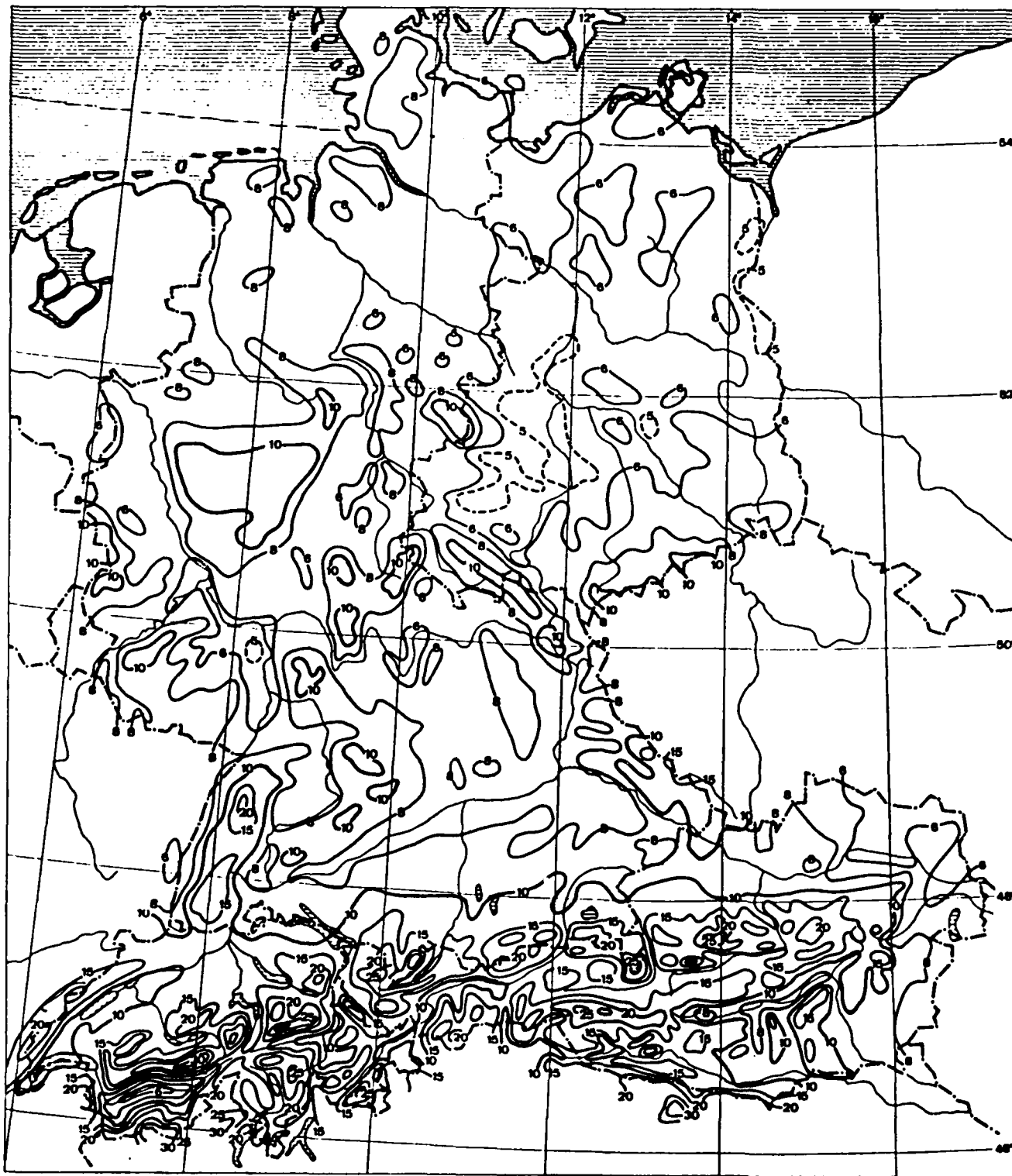


Fig. 22. Mean annual precipitation. Isohyets shown in decimetres (1931-1960).

Mean cloudiness (%) in January 1931-1960

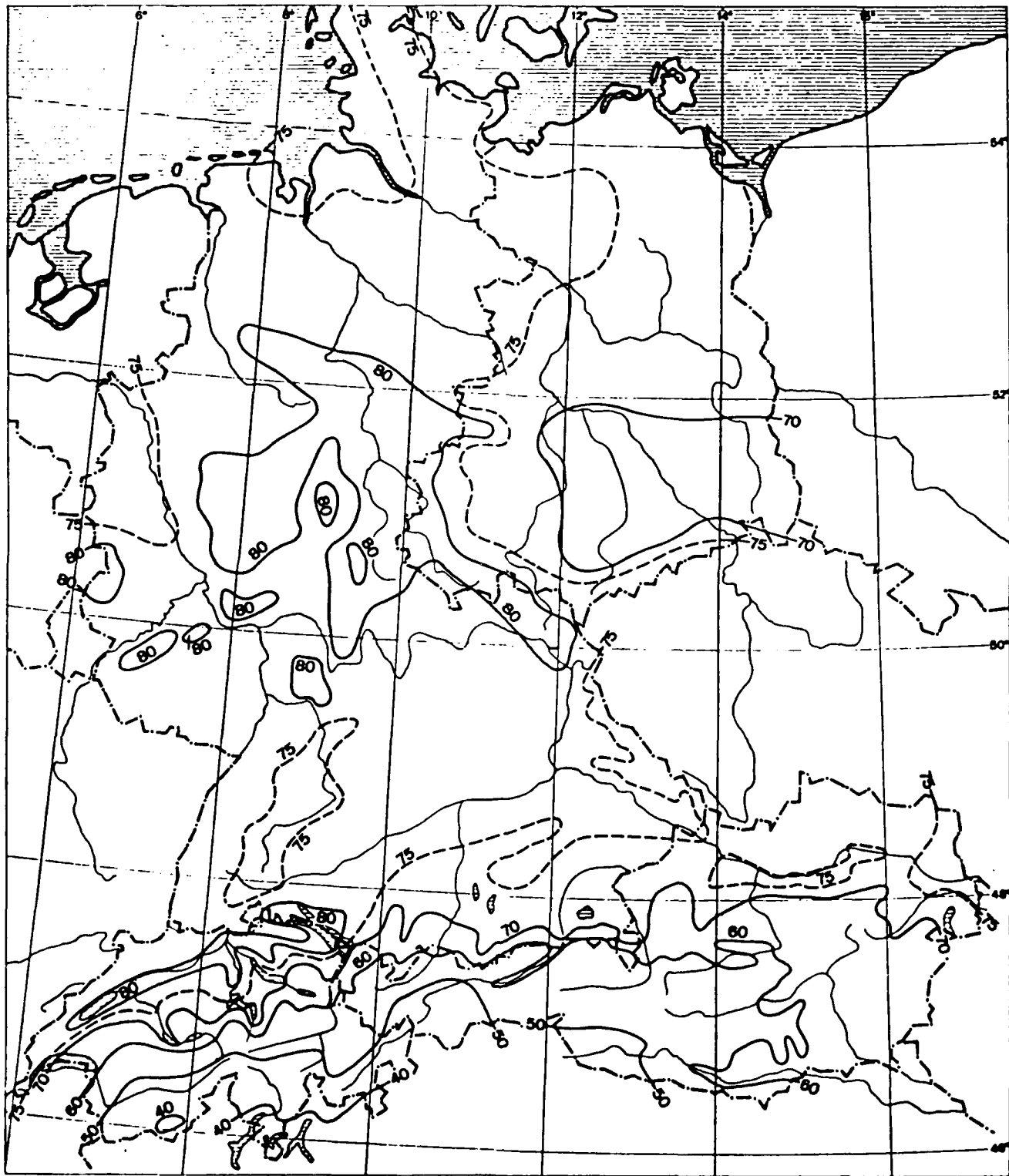


Fig.25. Mean cloudiness (%) in January, 1931-1960.

Mean cloudiness (%) in July 1931-1960

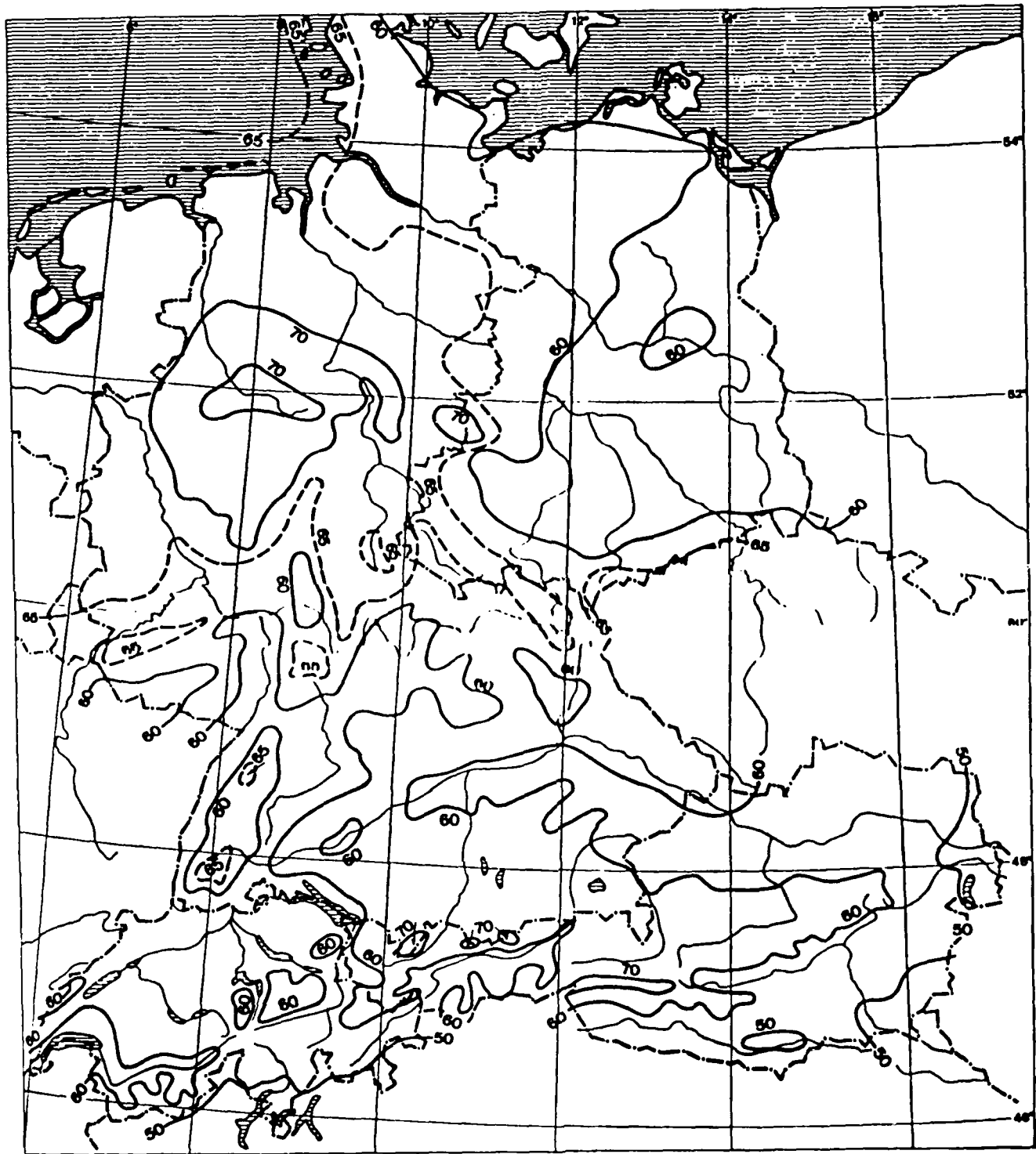


Fig.26. Mean cloudiness (%) in July, 1931-1960.

Annual mean wind distribution; figures in the circles are calms (% 1 mm is 1.9%)

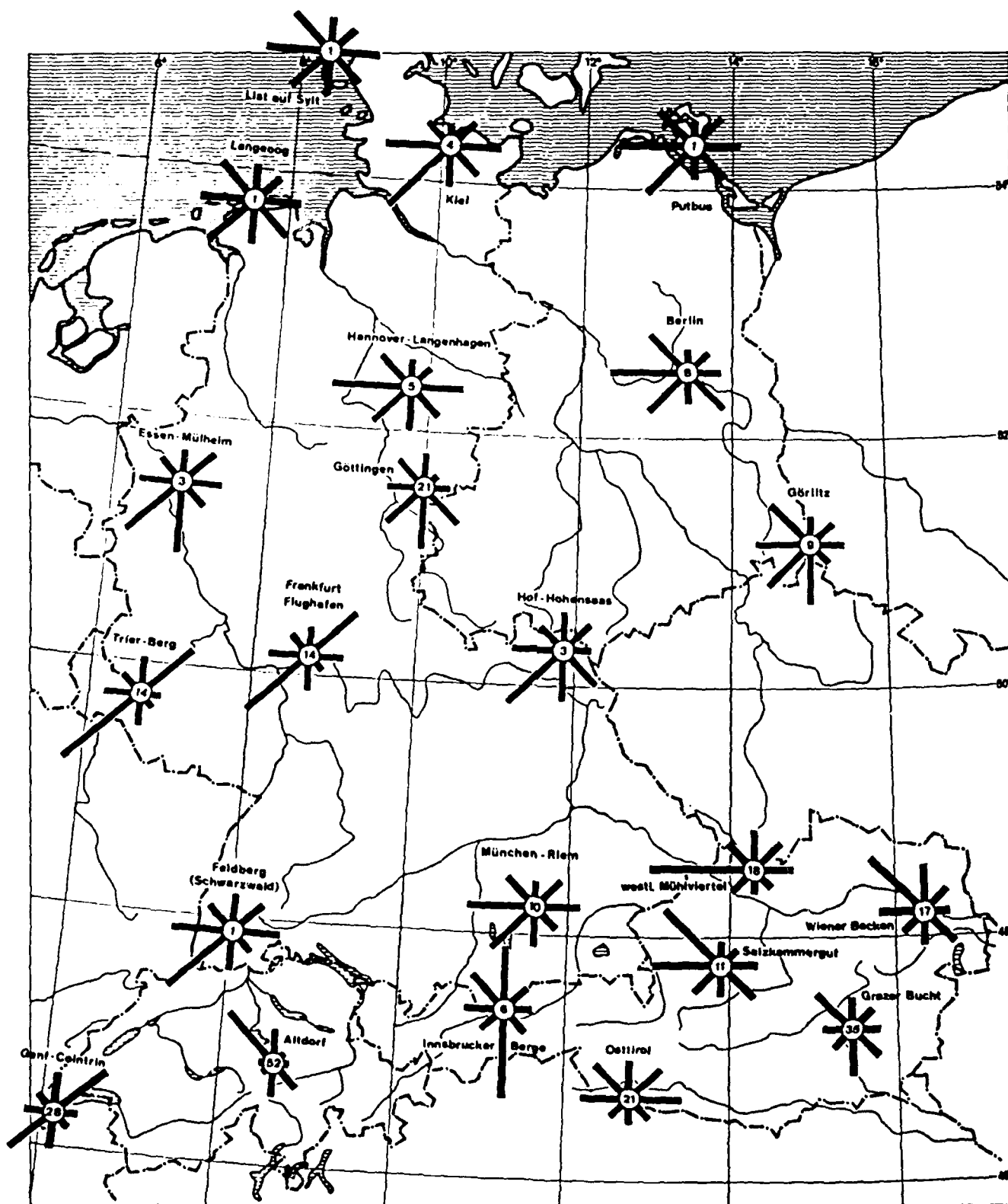
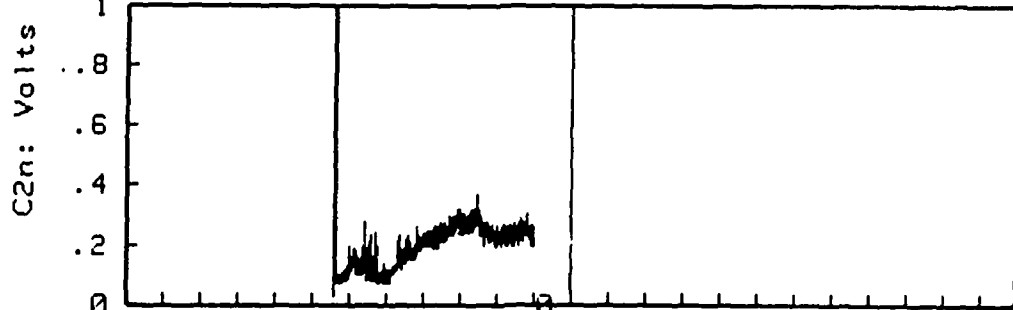
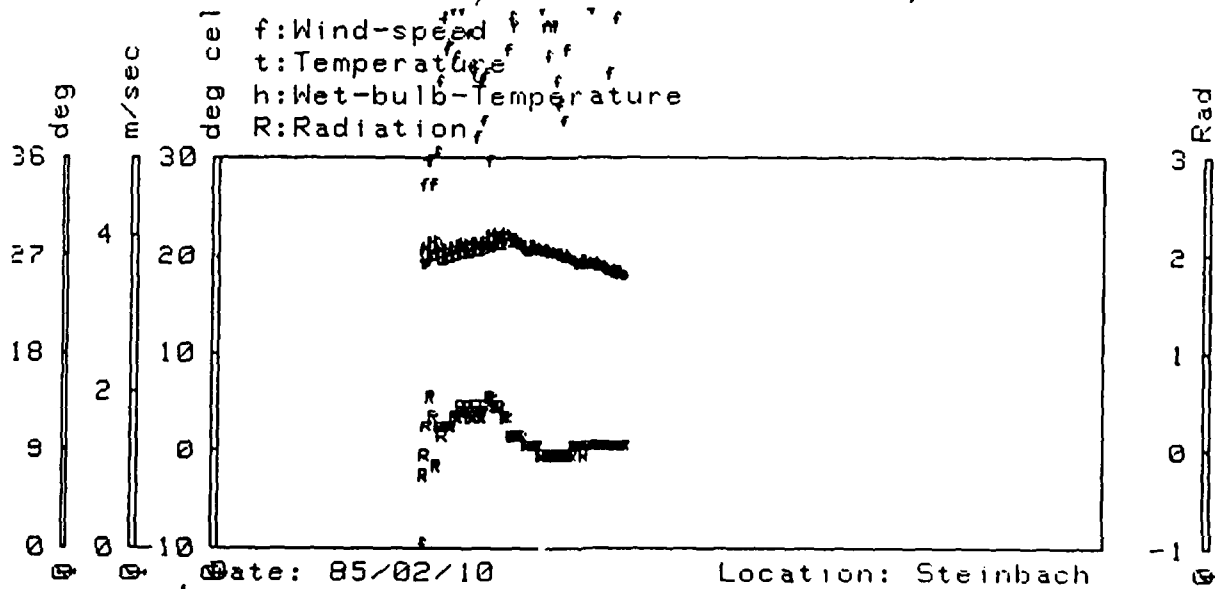
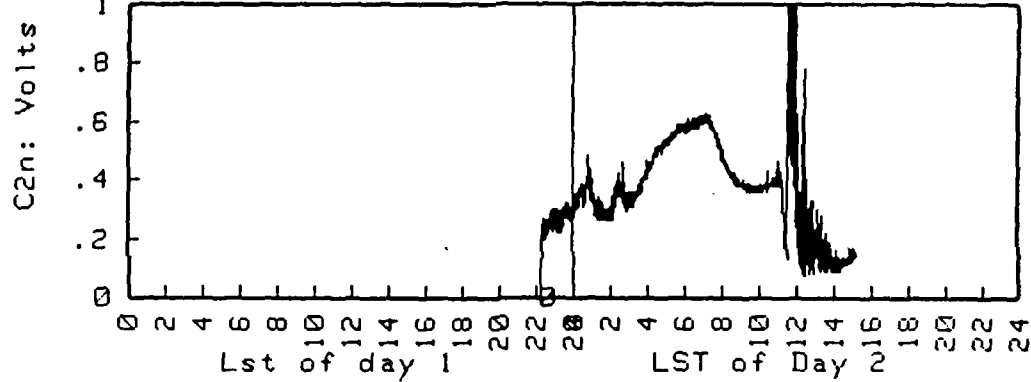
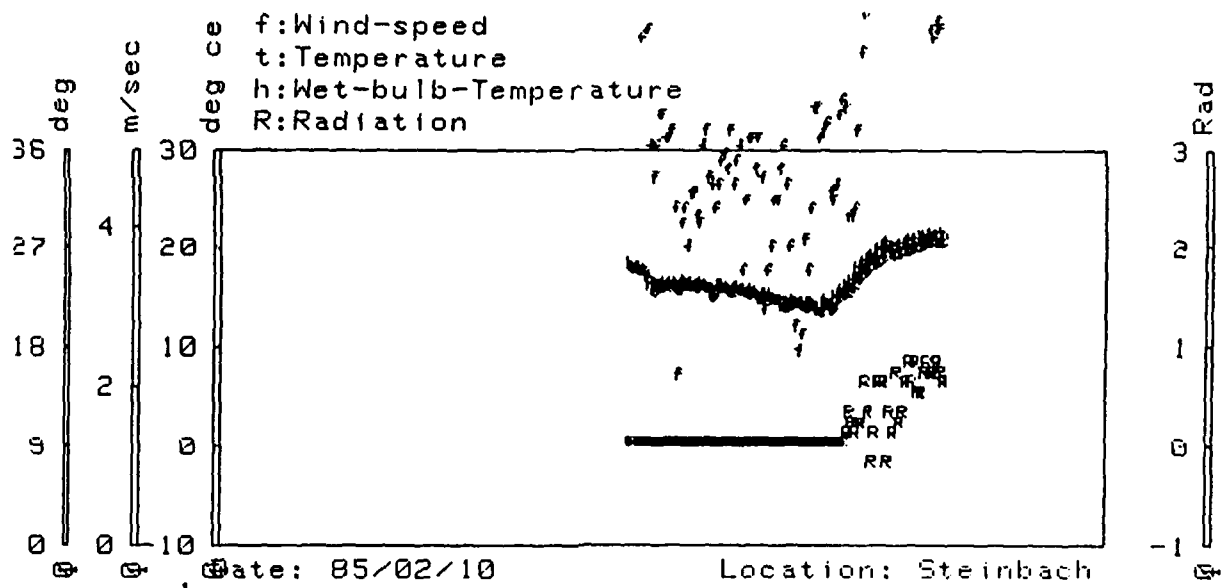
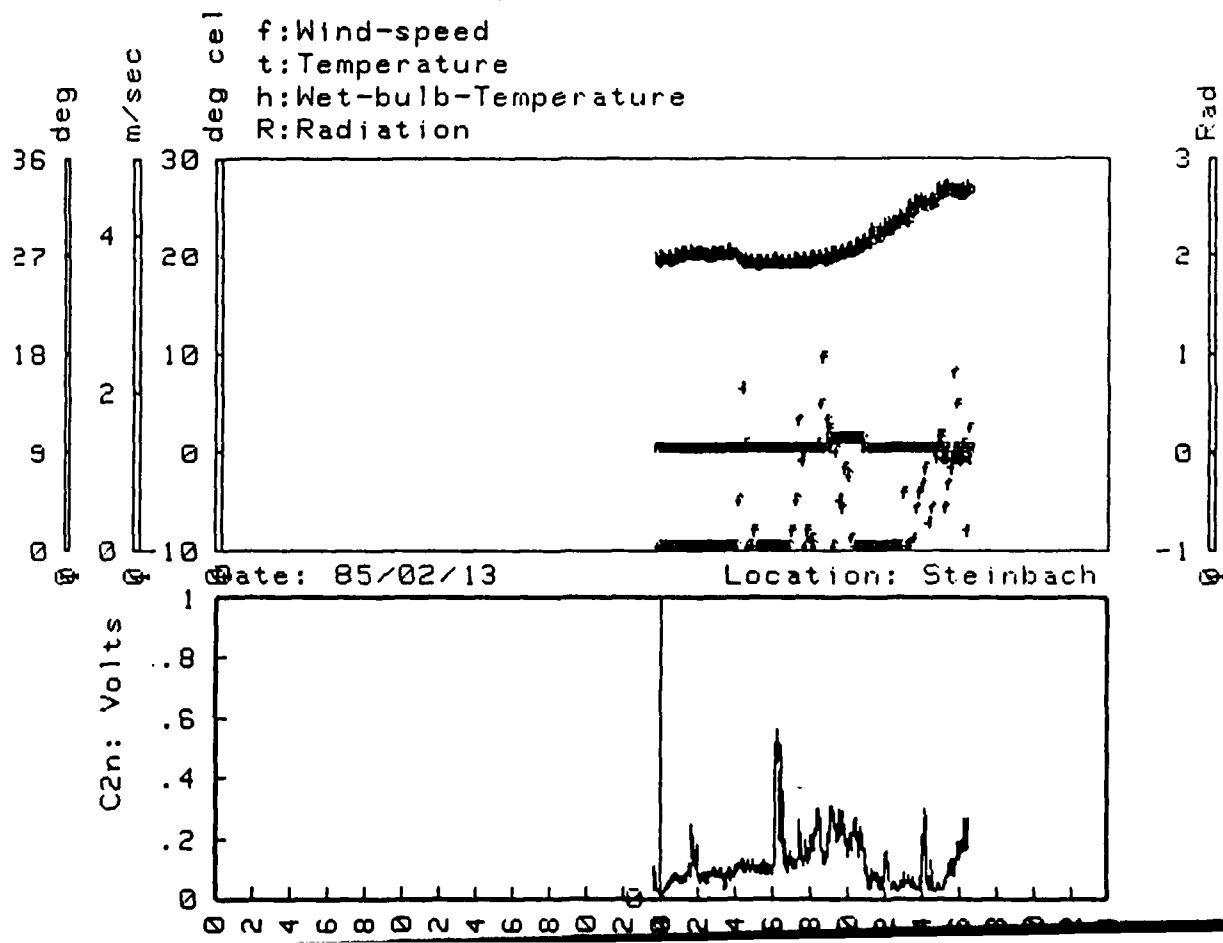
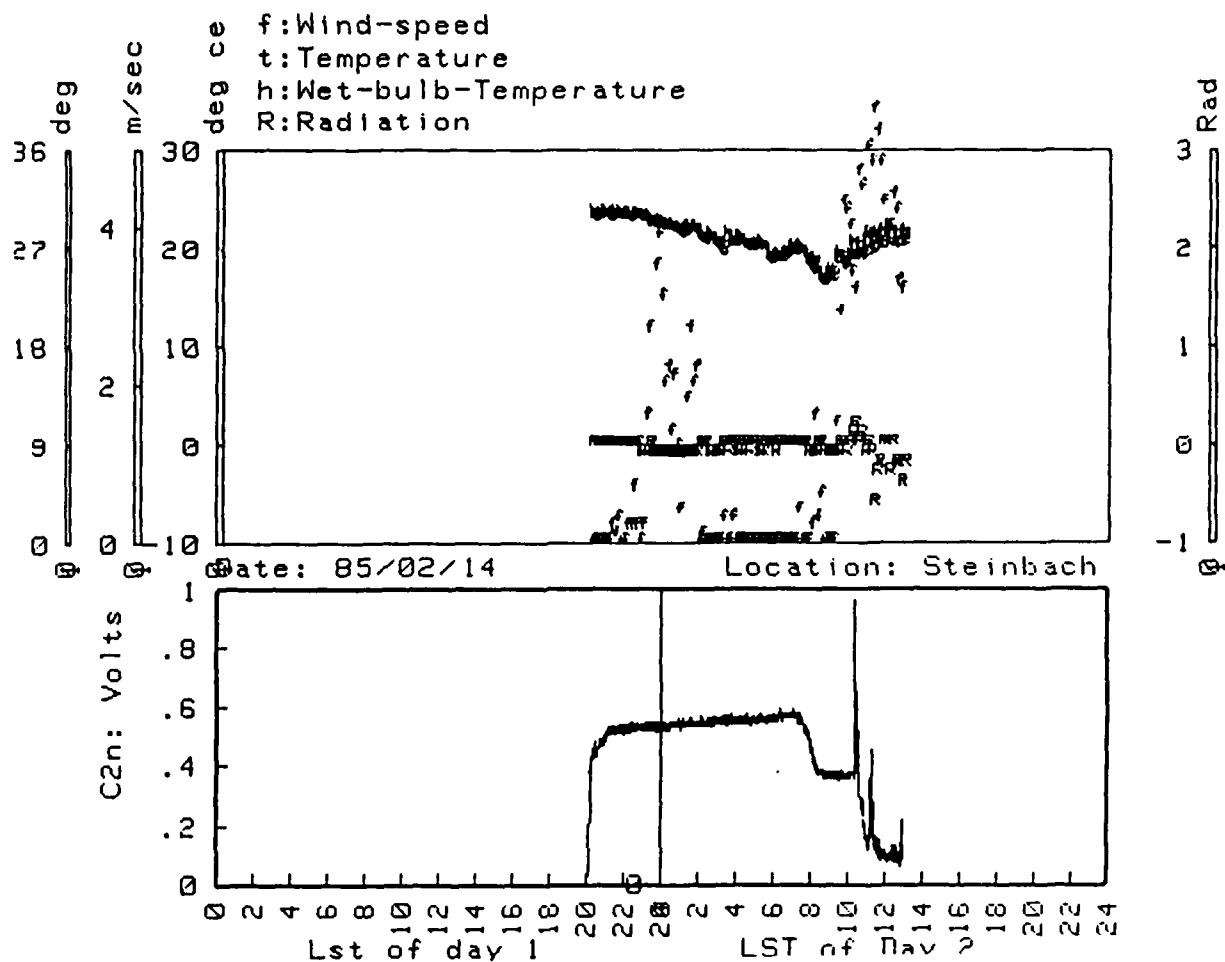
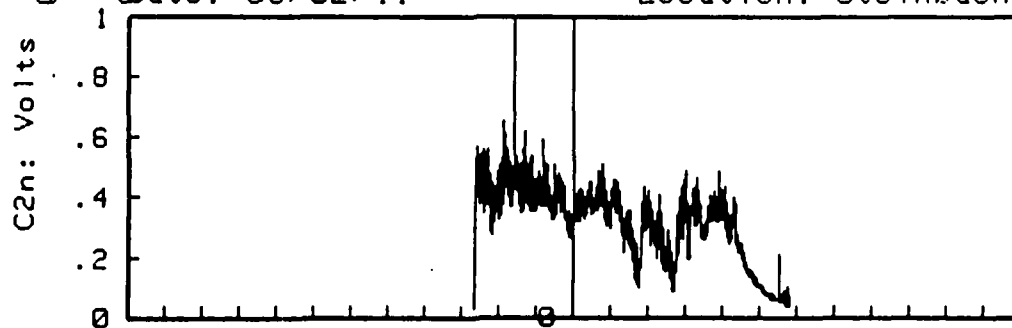
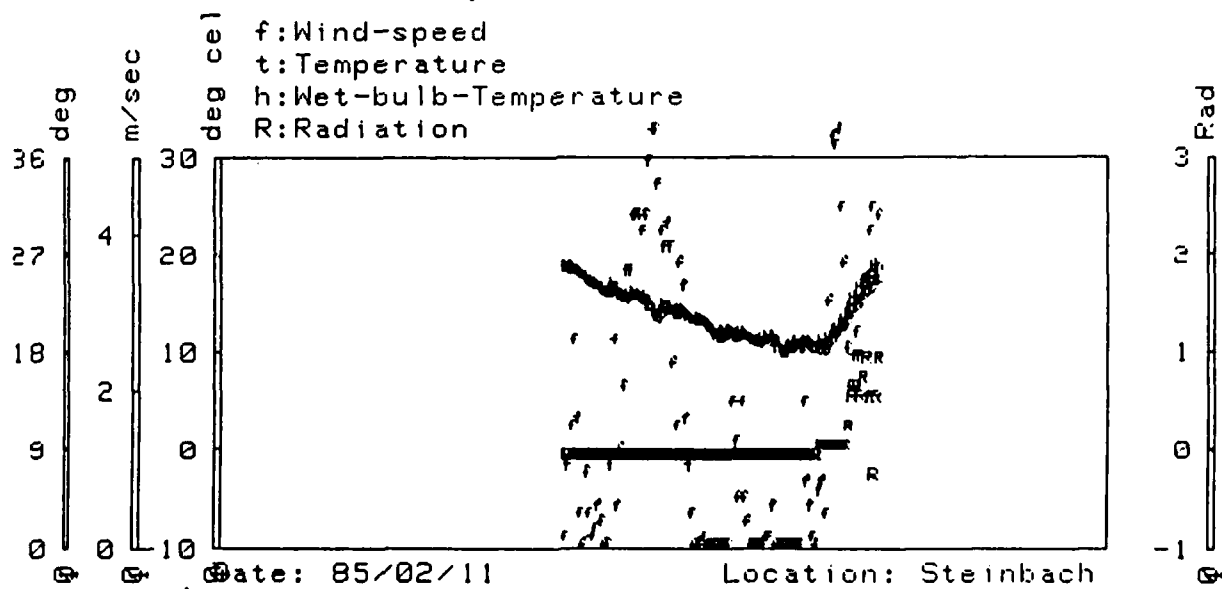
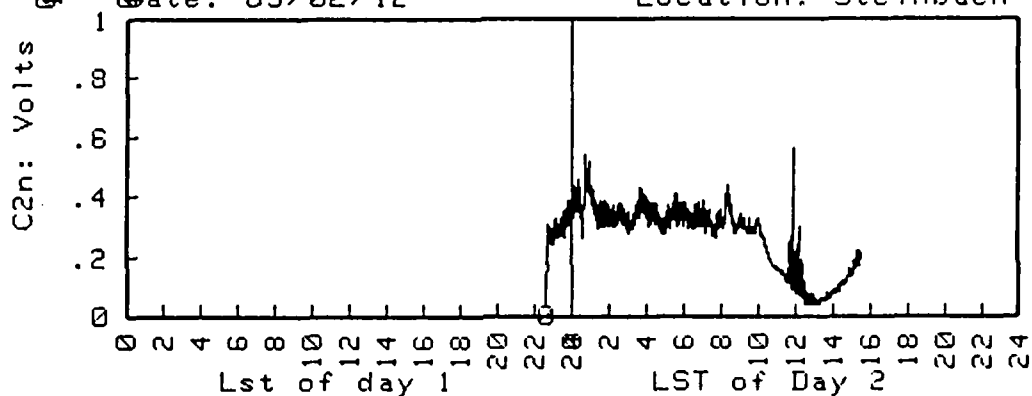
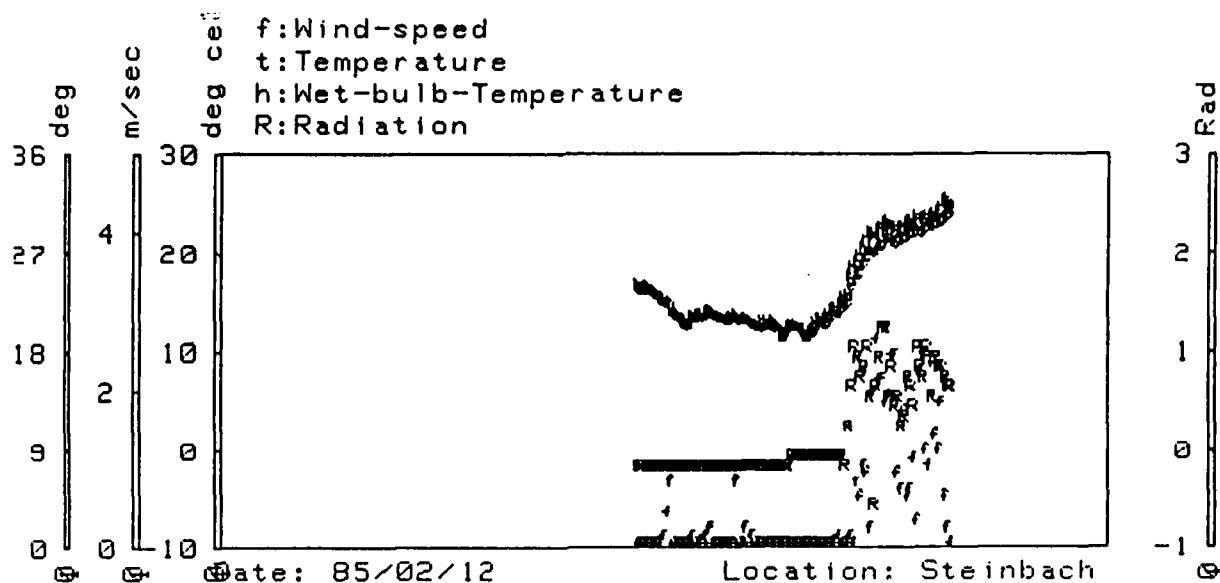
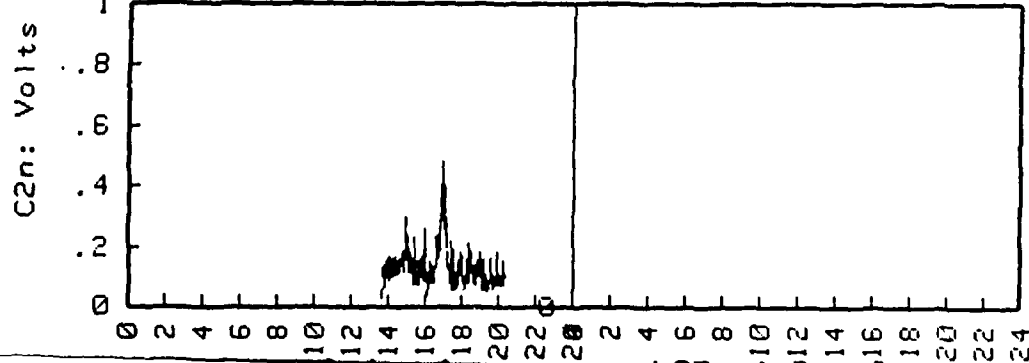
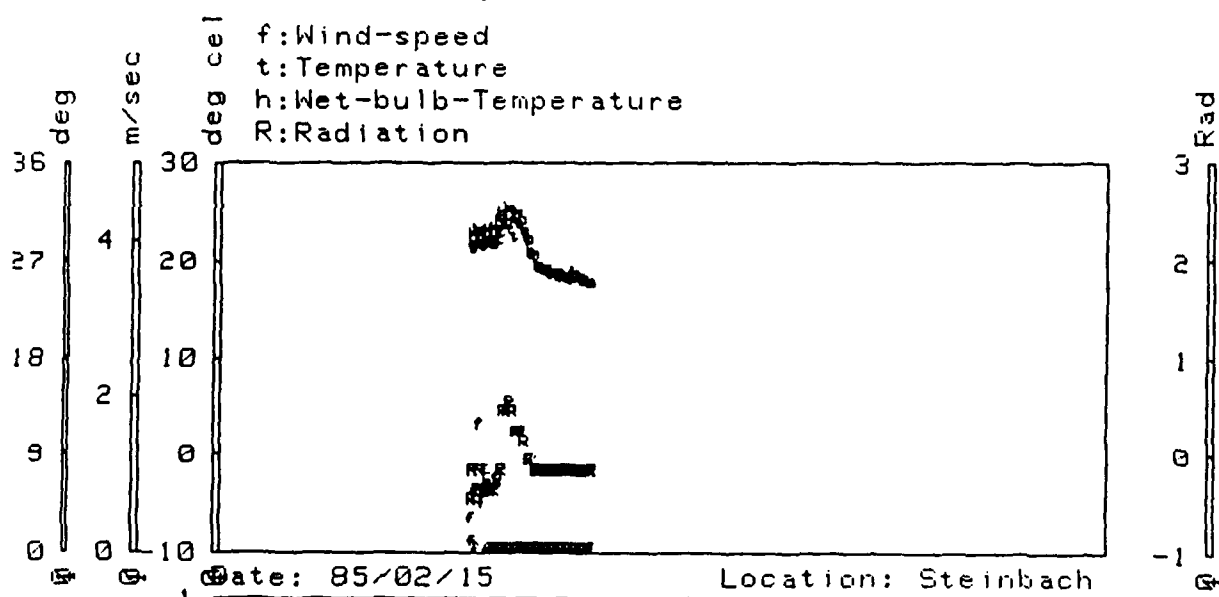
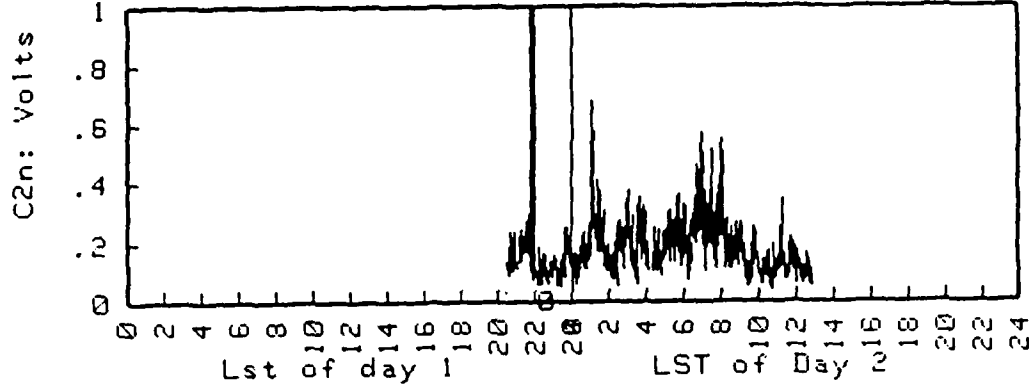
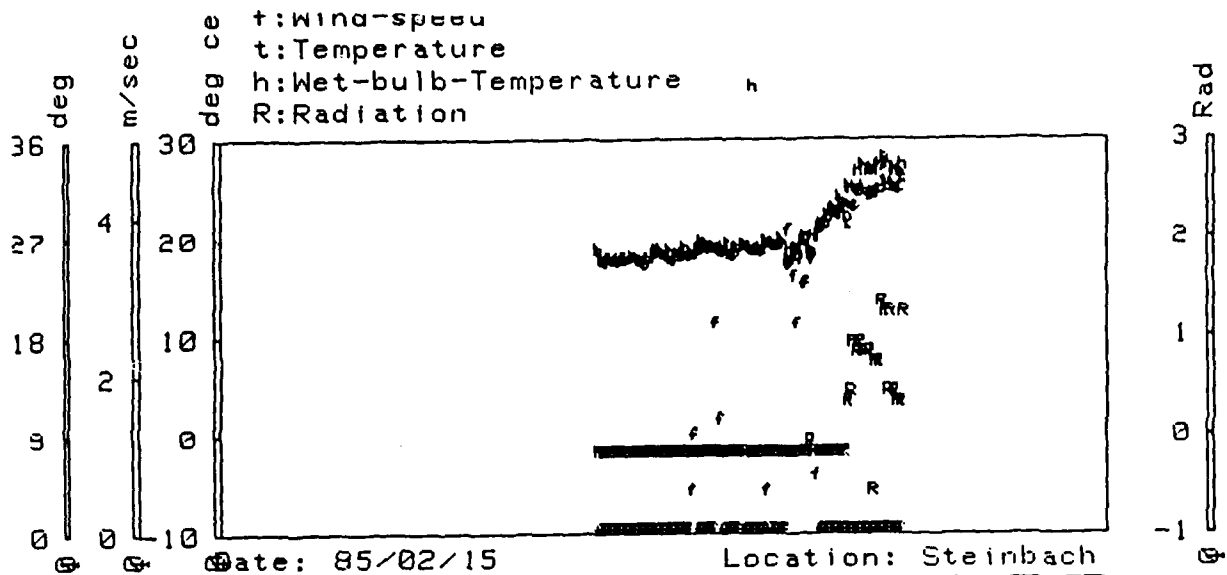


Fig. 27. Annual mean wind distribution; figures in the circles are calms (%; 1 mm is 1.9%).

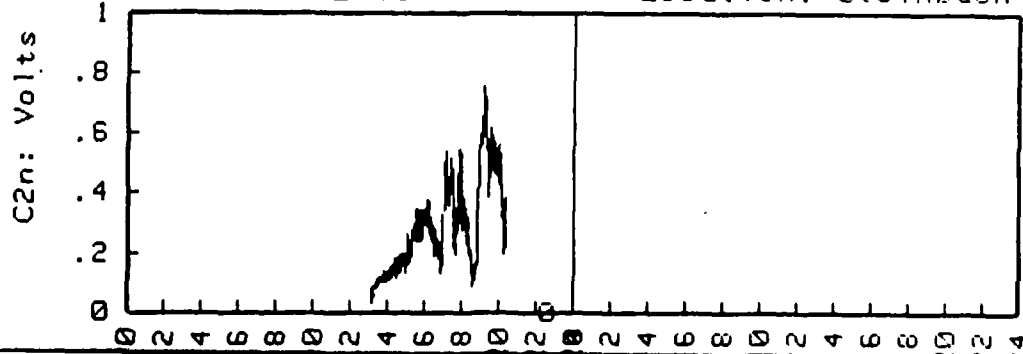
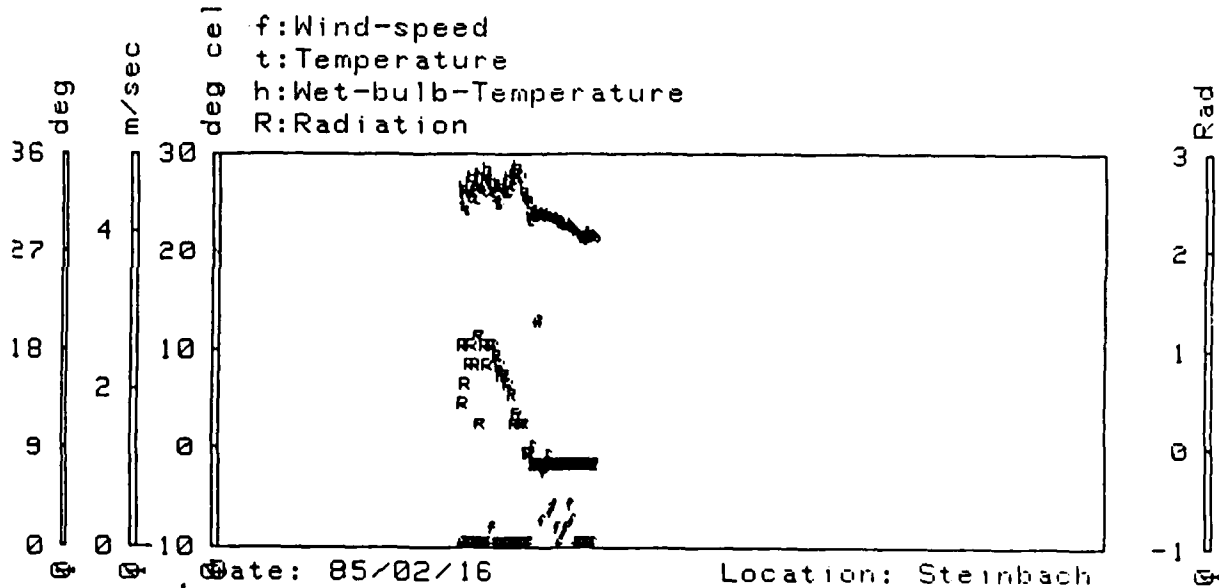
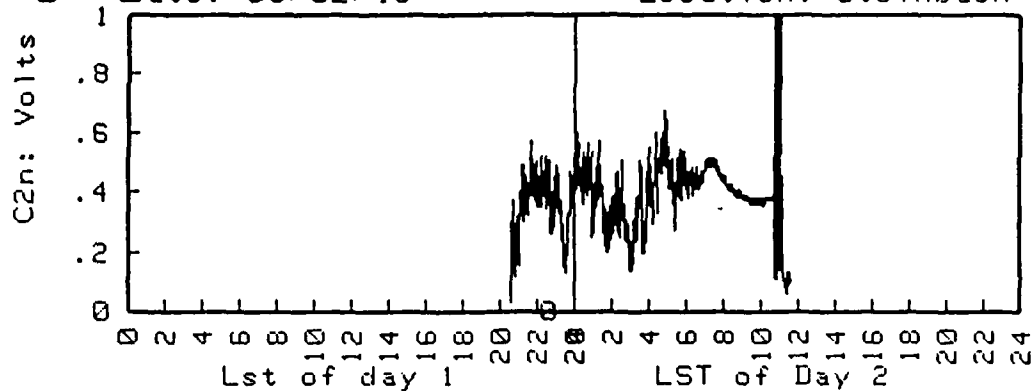
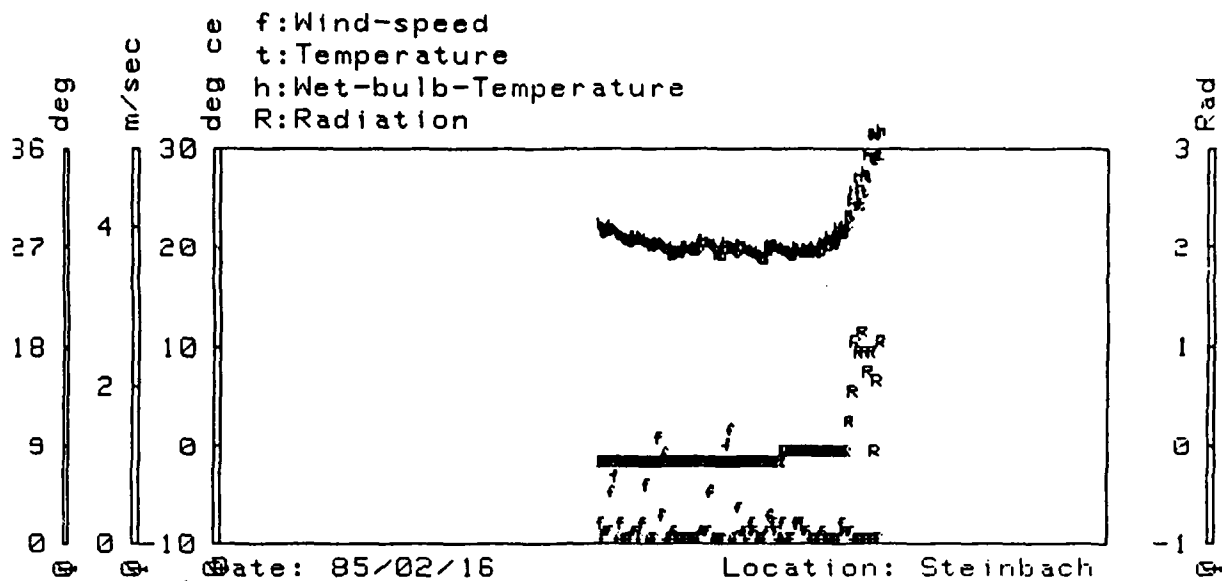


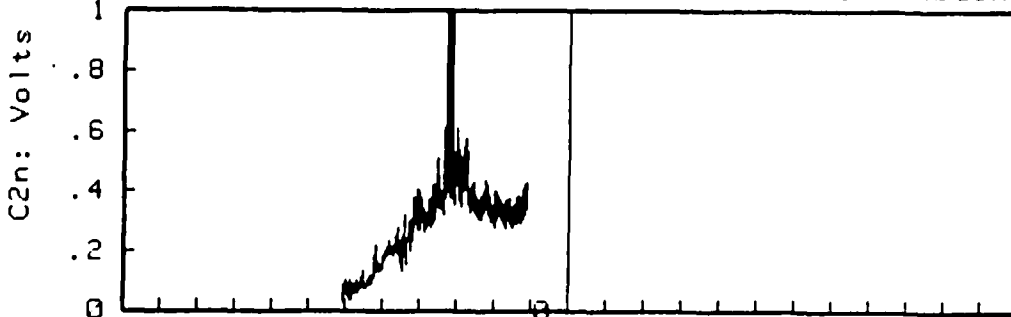
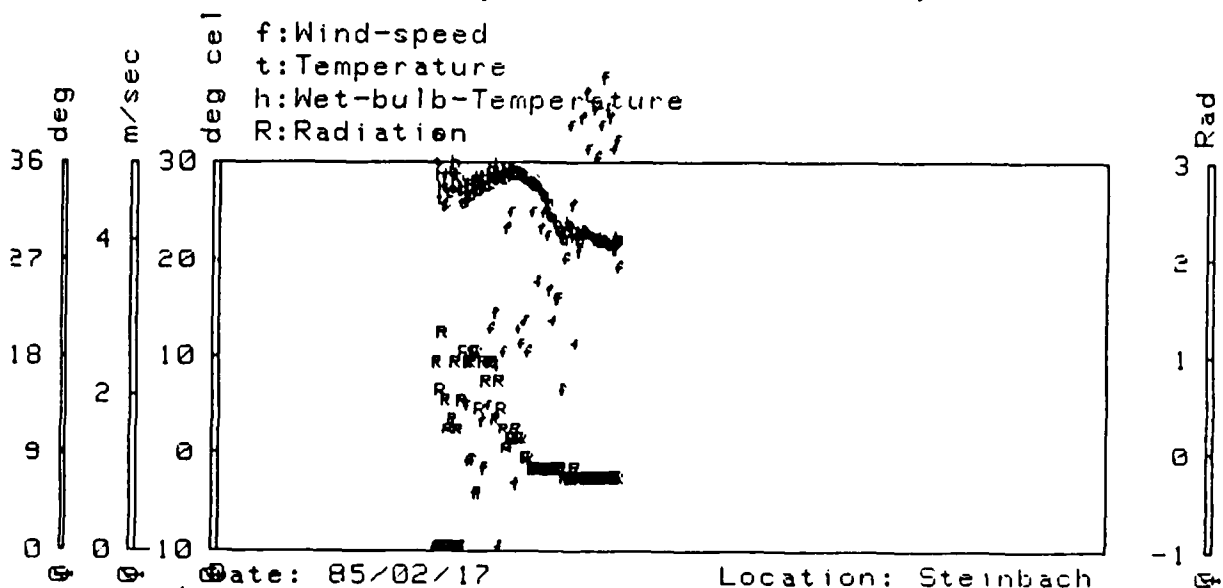
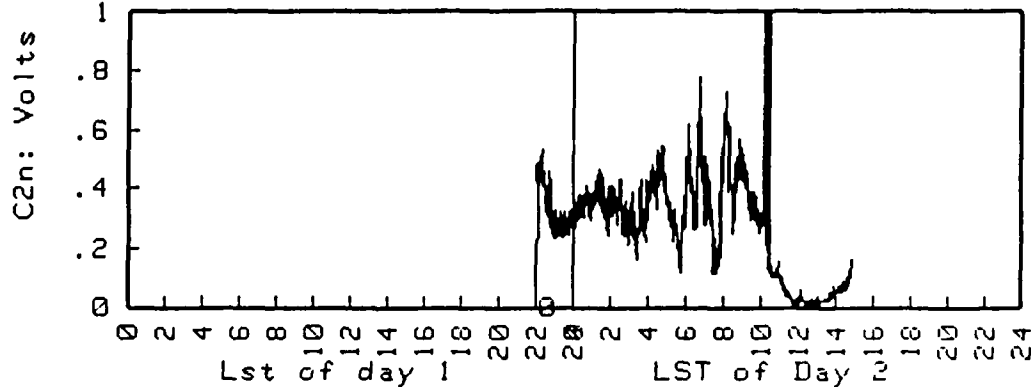
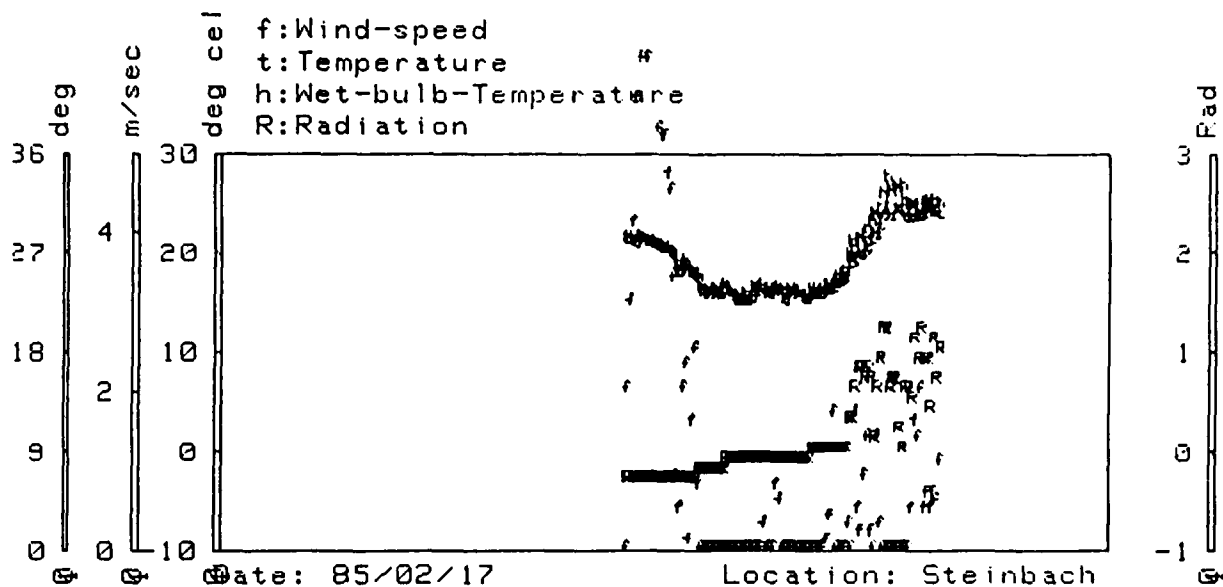


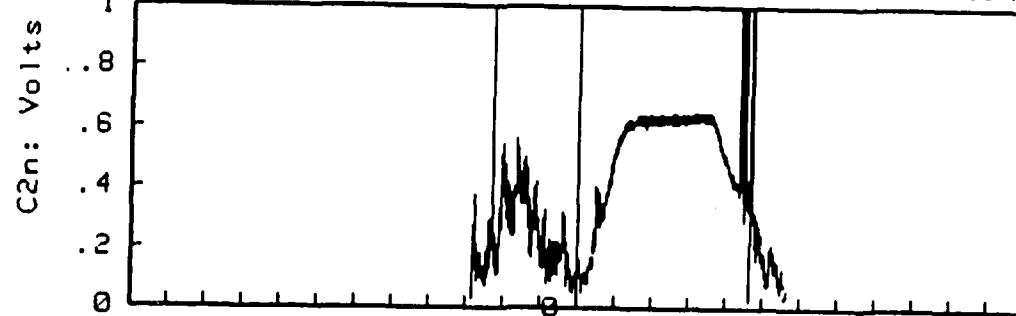
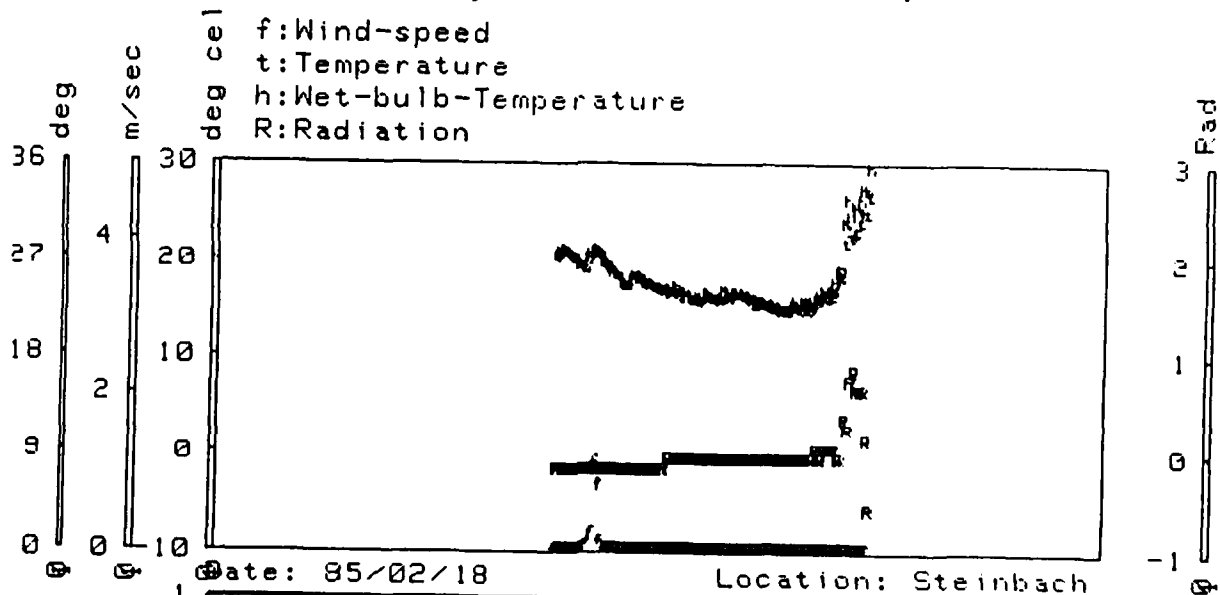
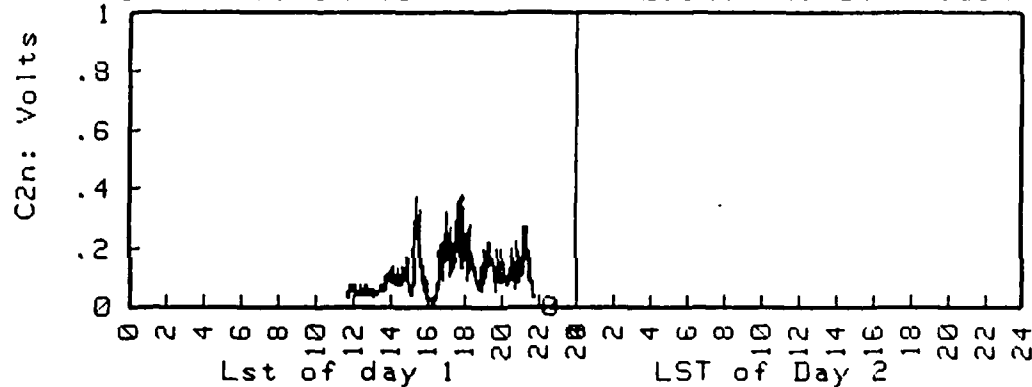
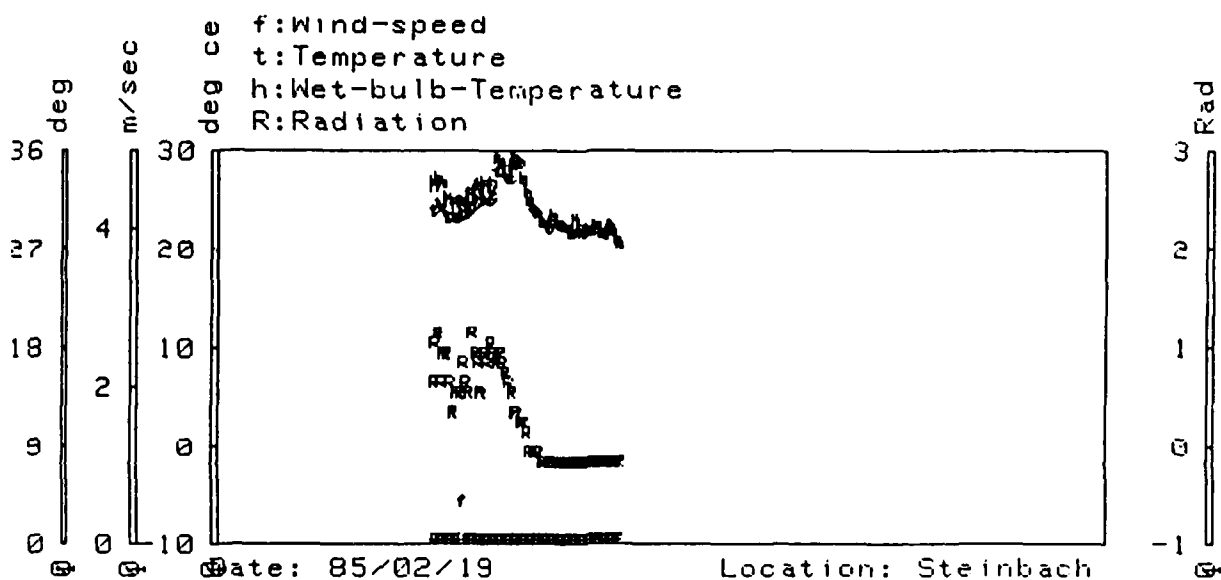


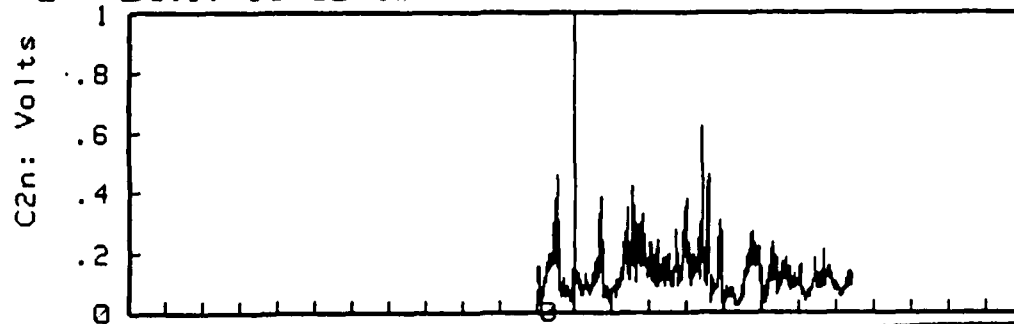
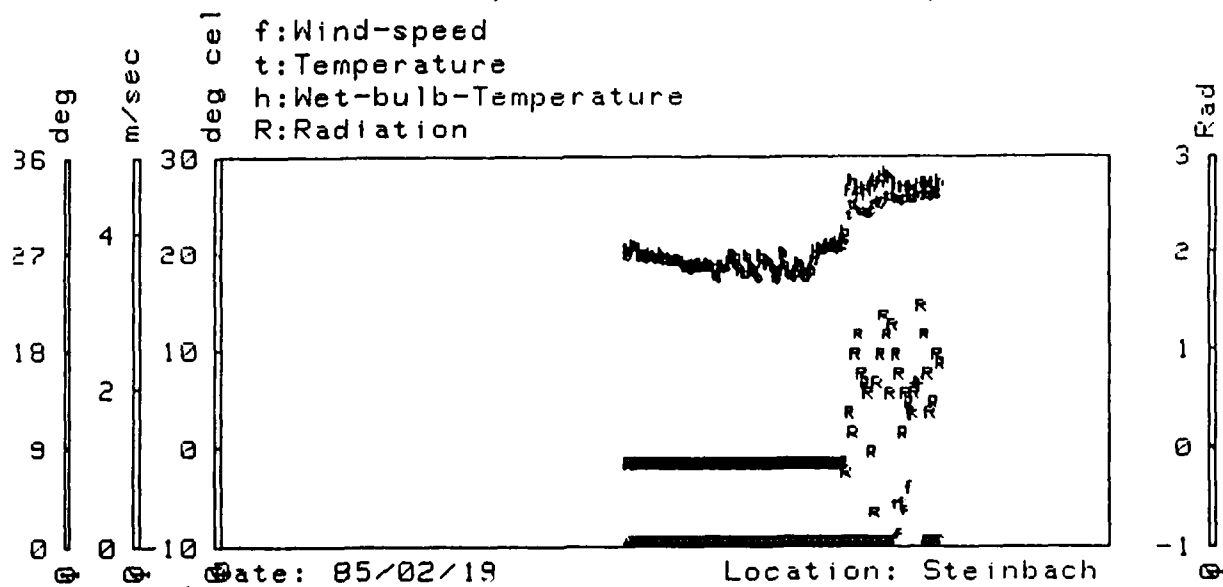
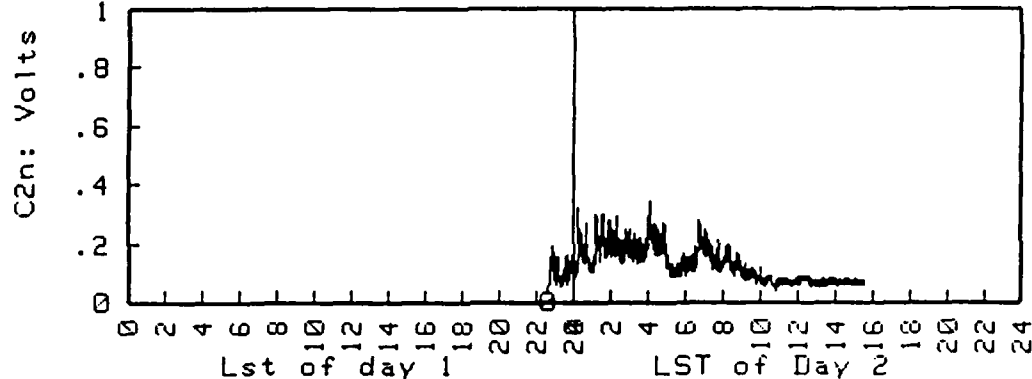
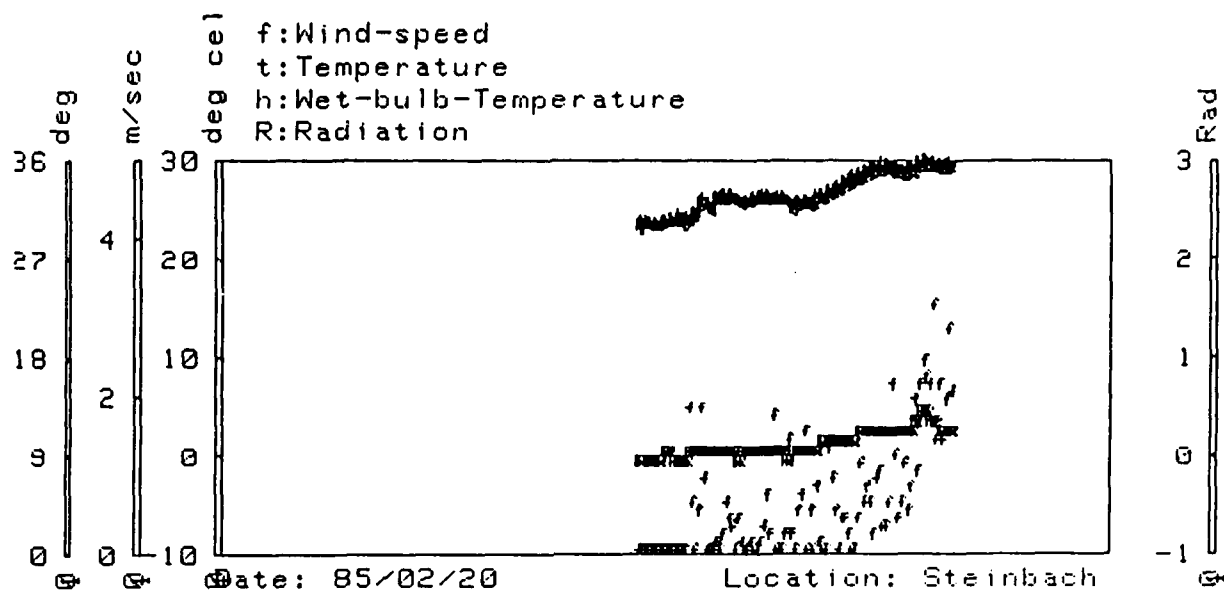


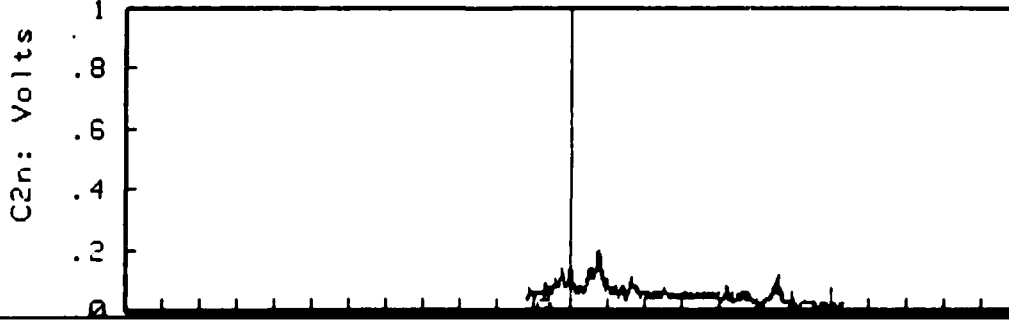
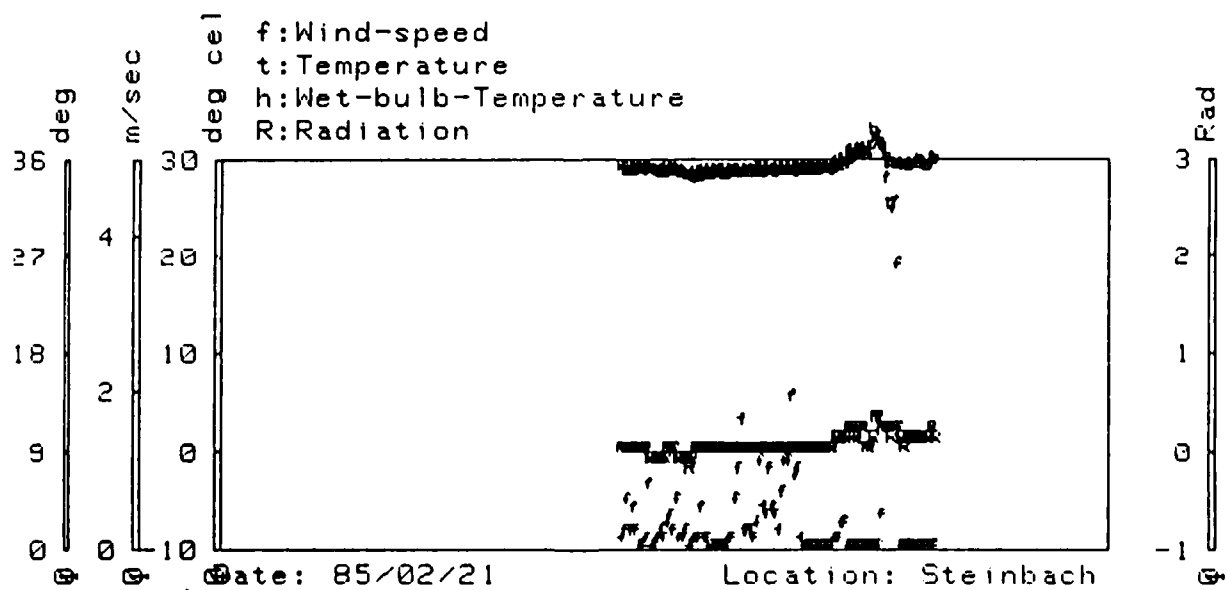
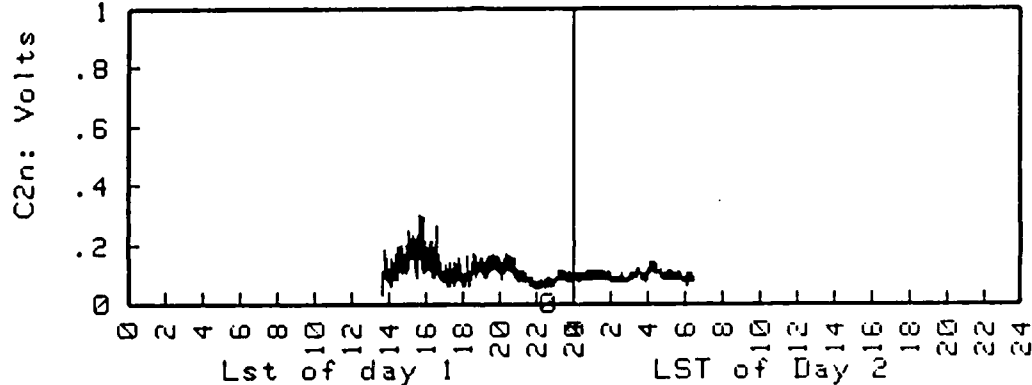
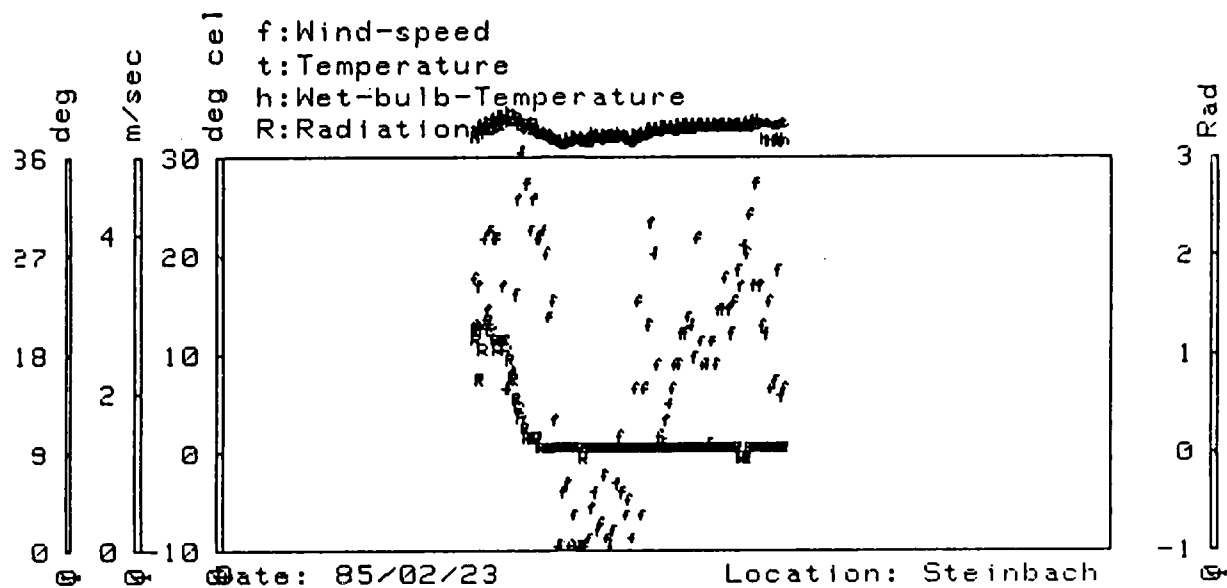


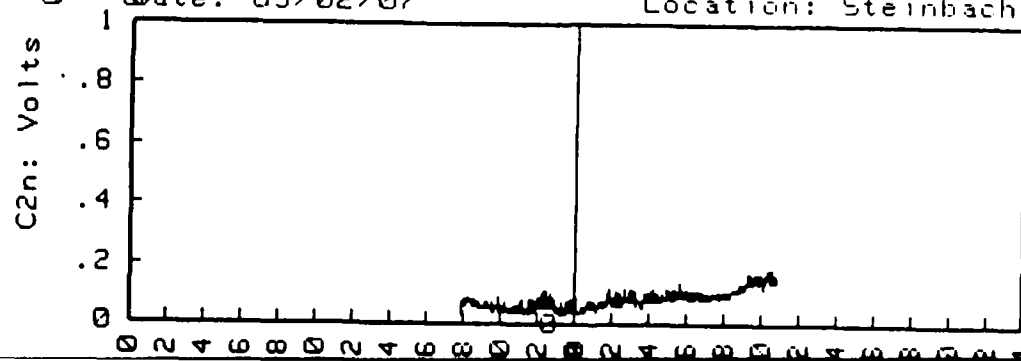
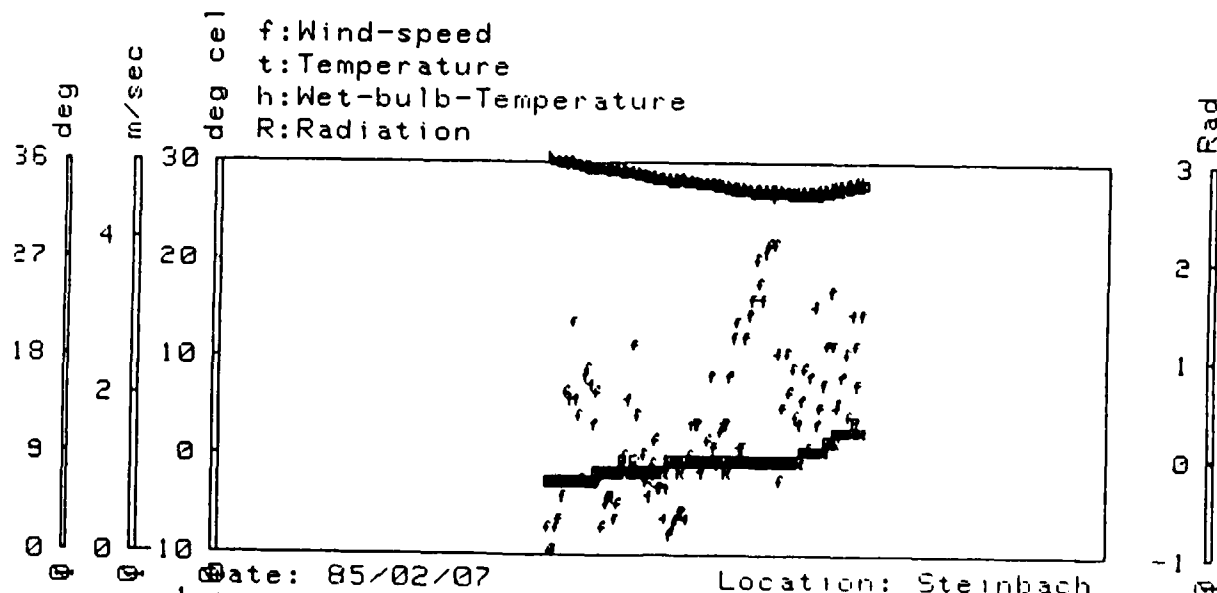
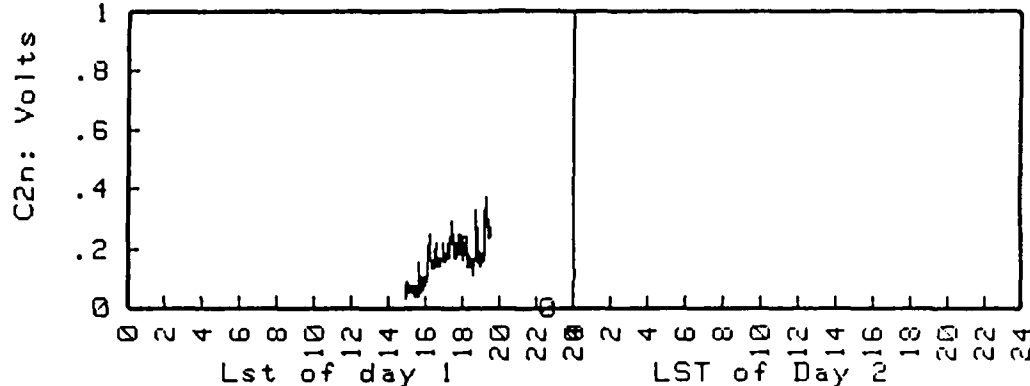
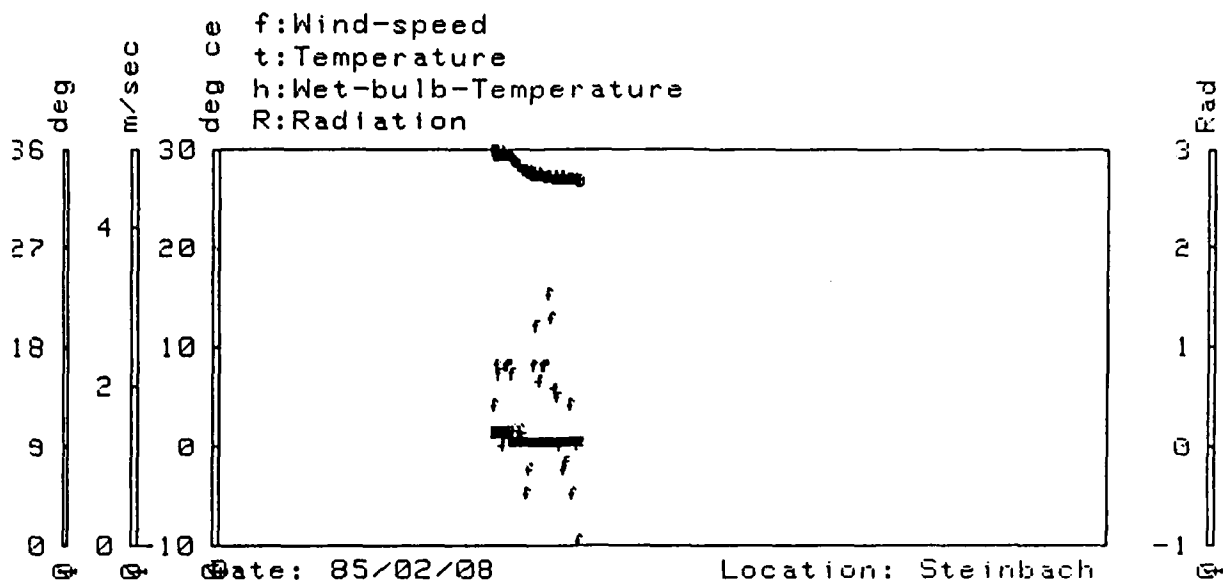


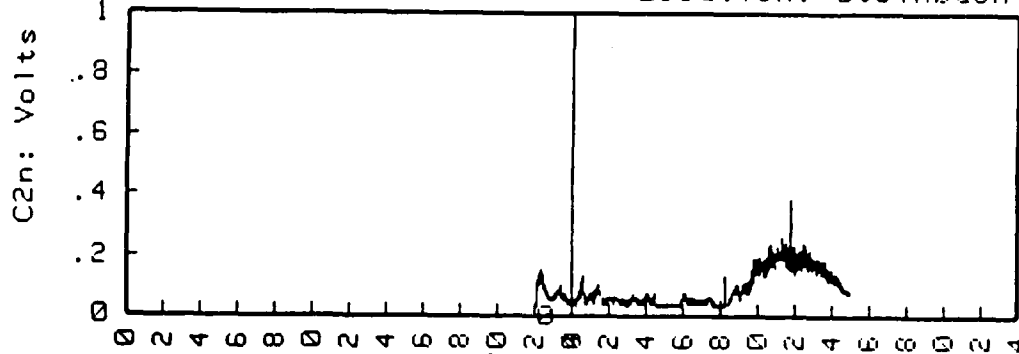
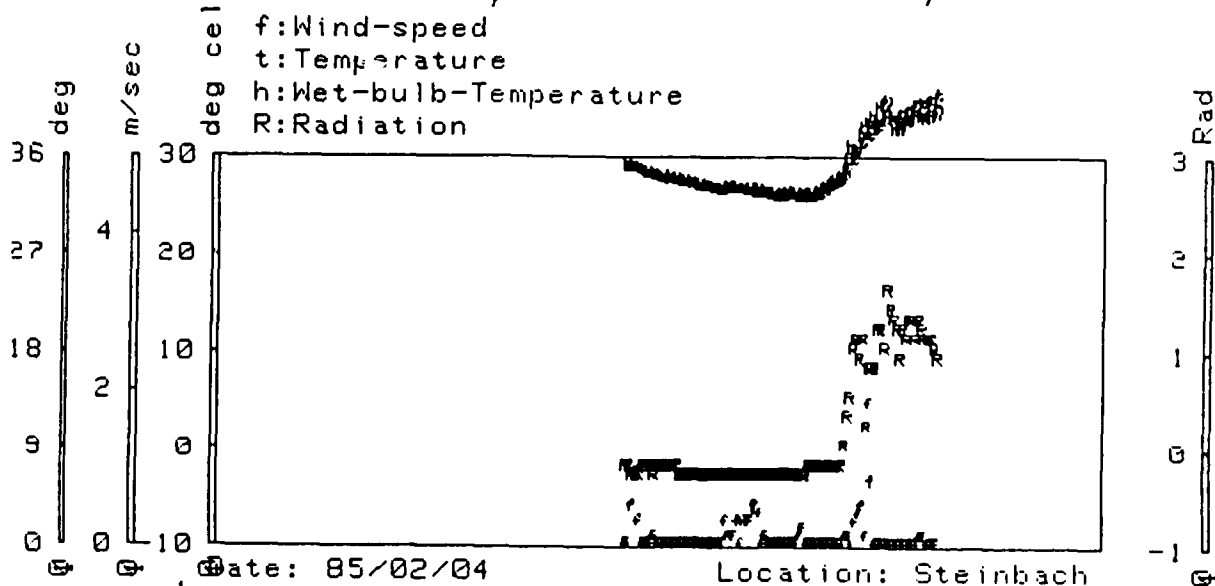
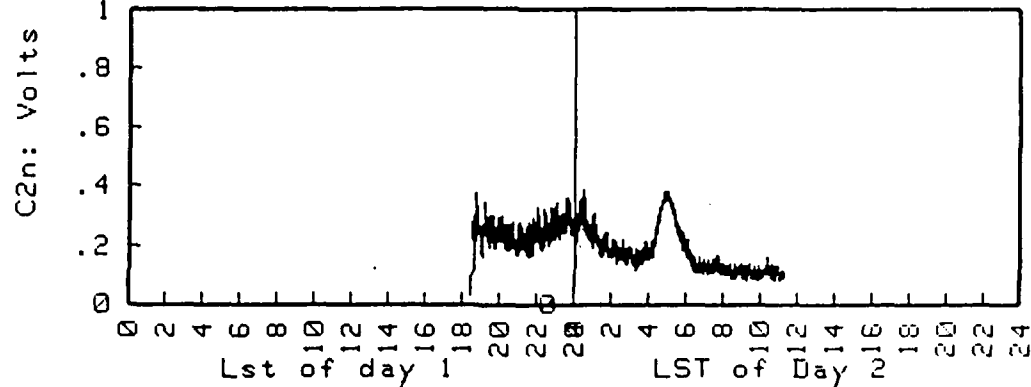
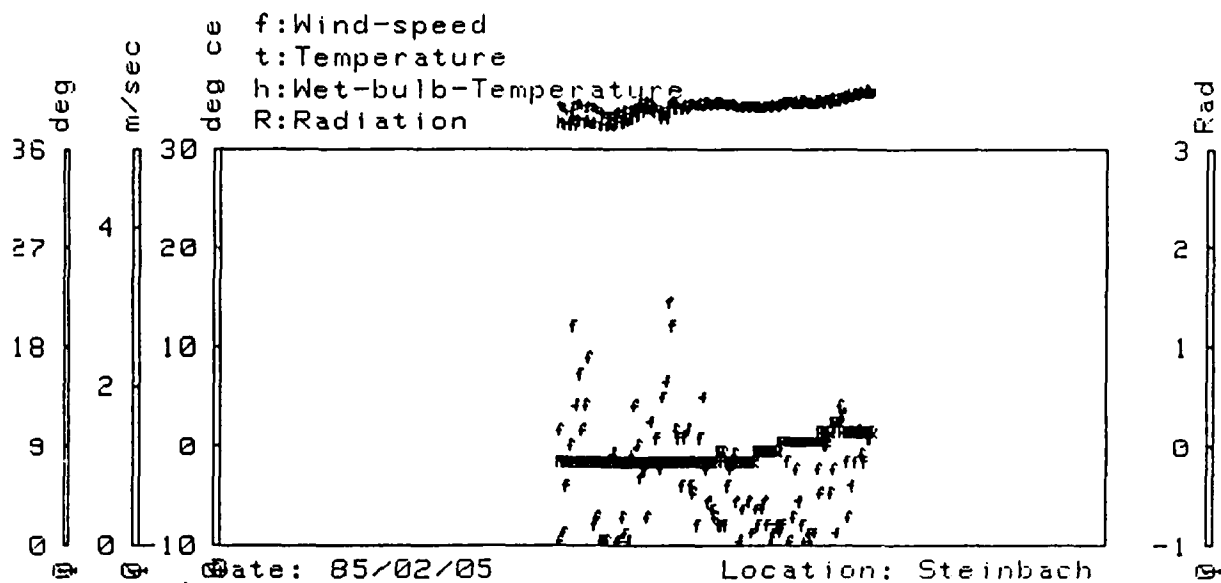


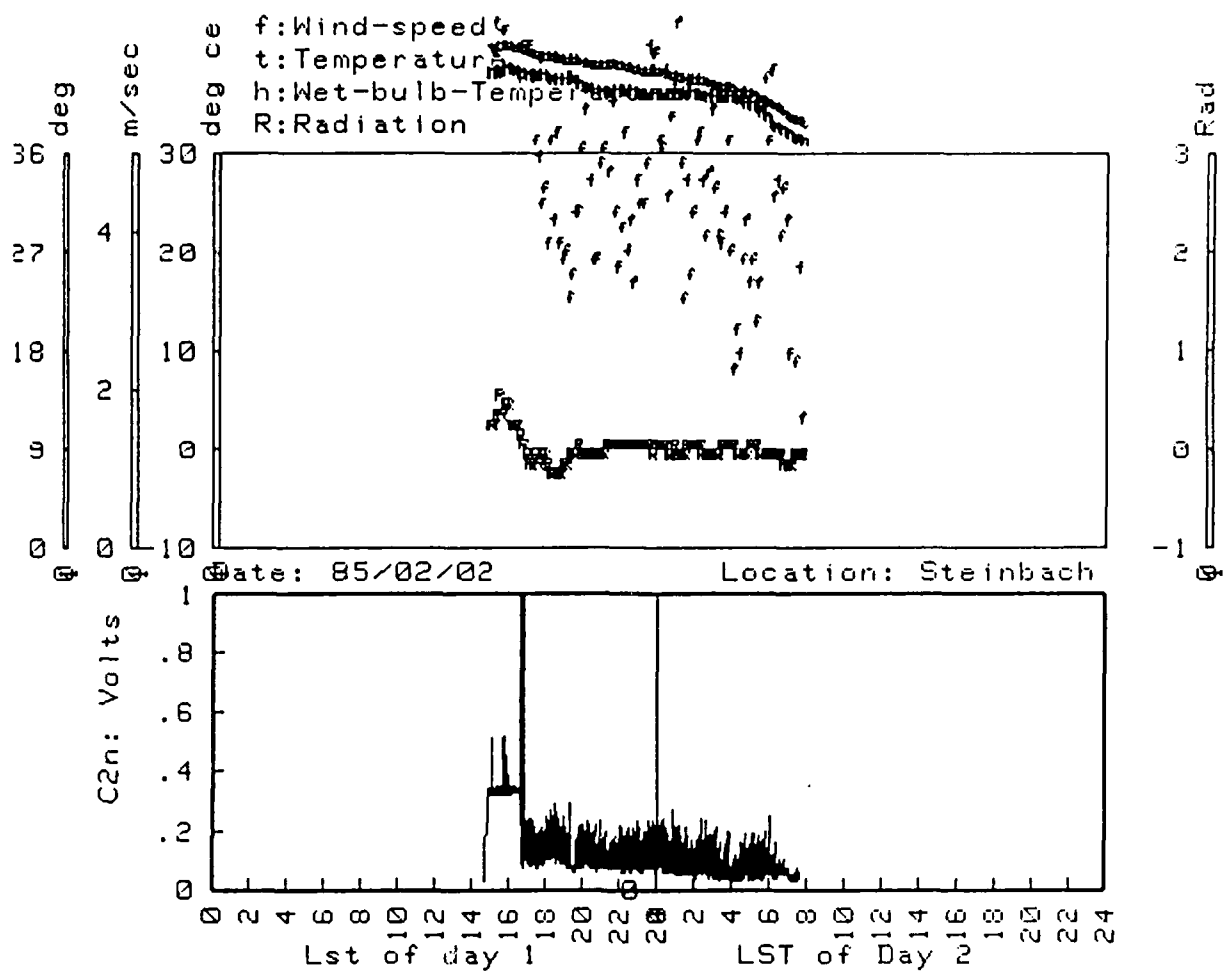




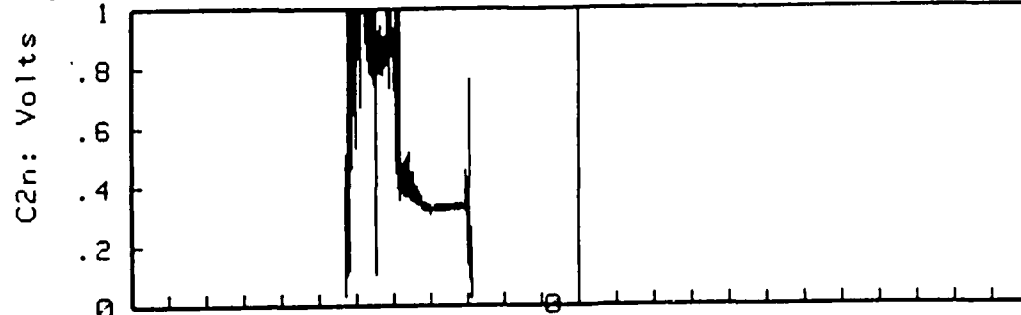
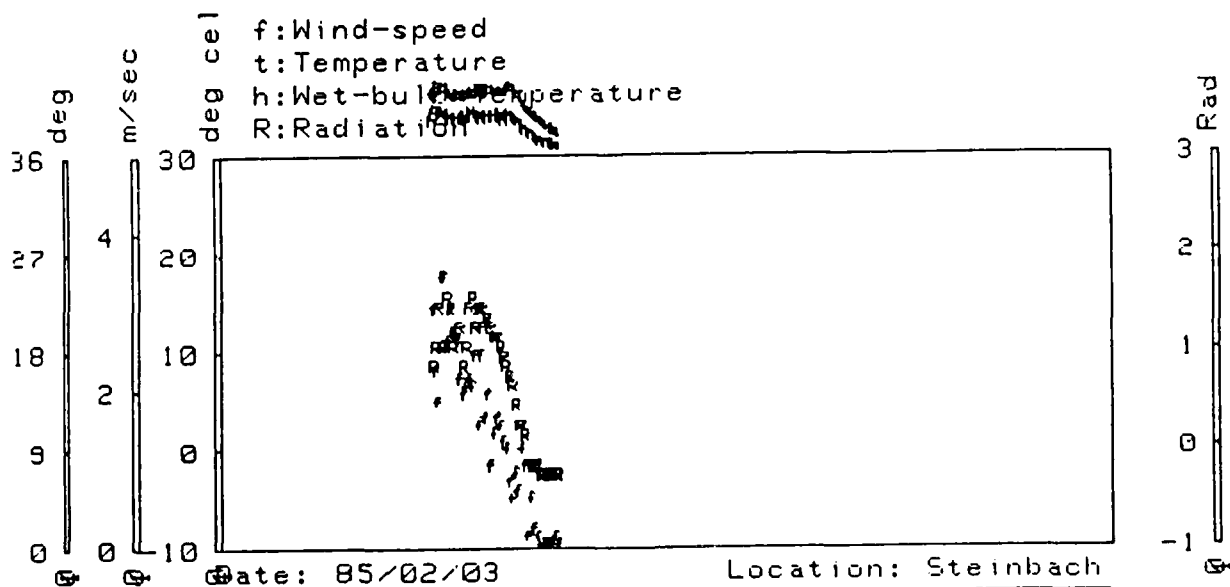
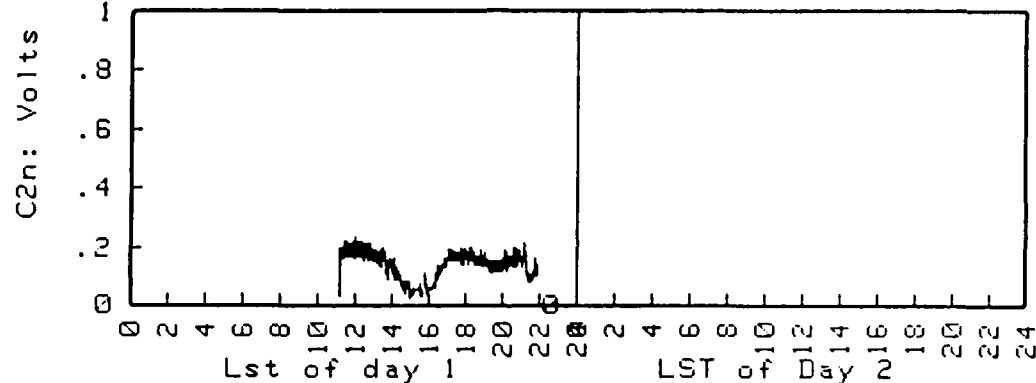
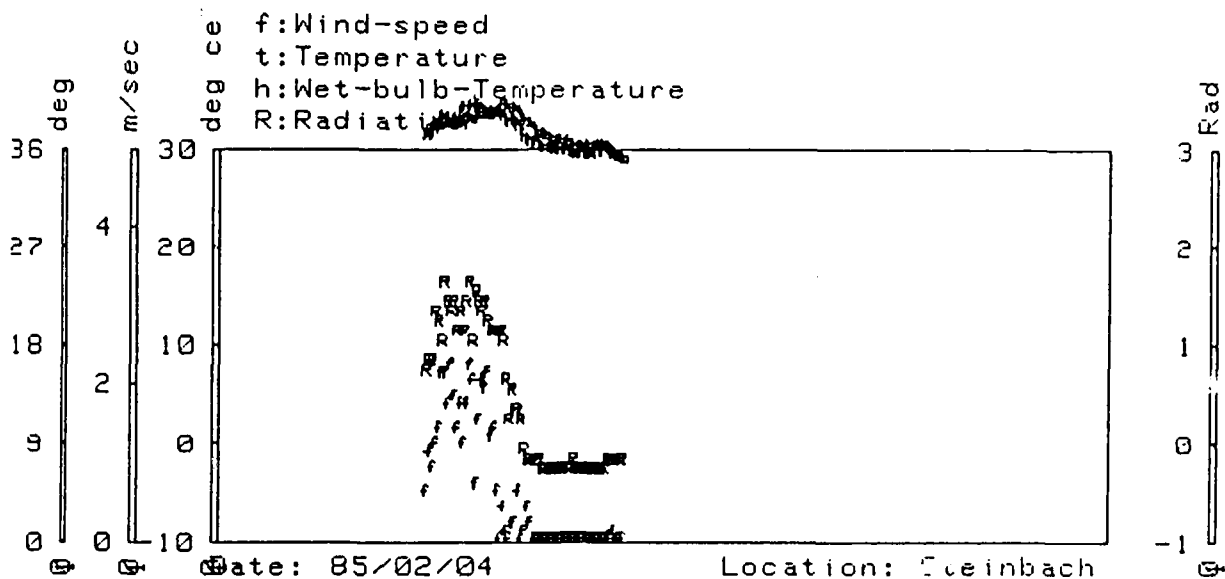


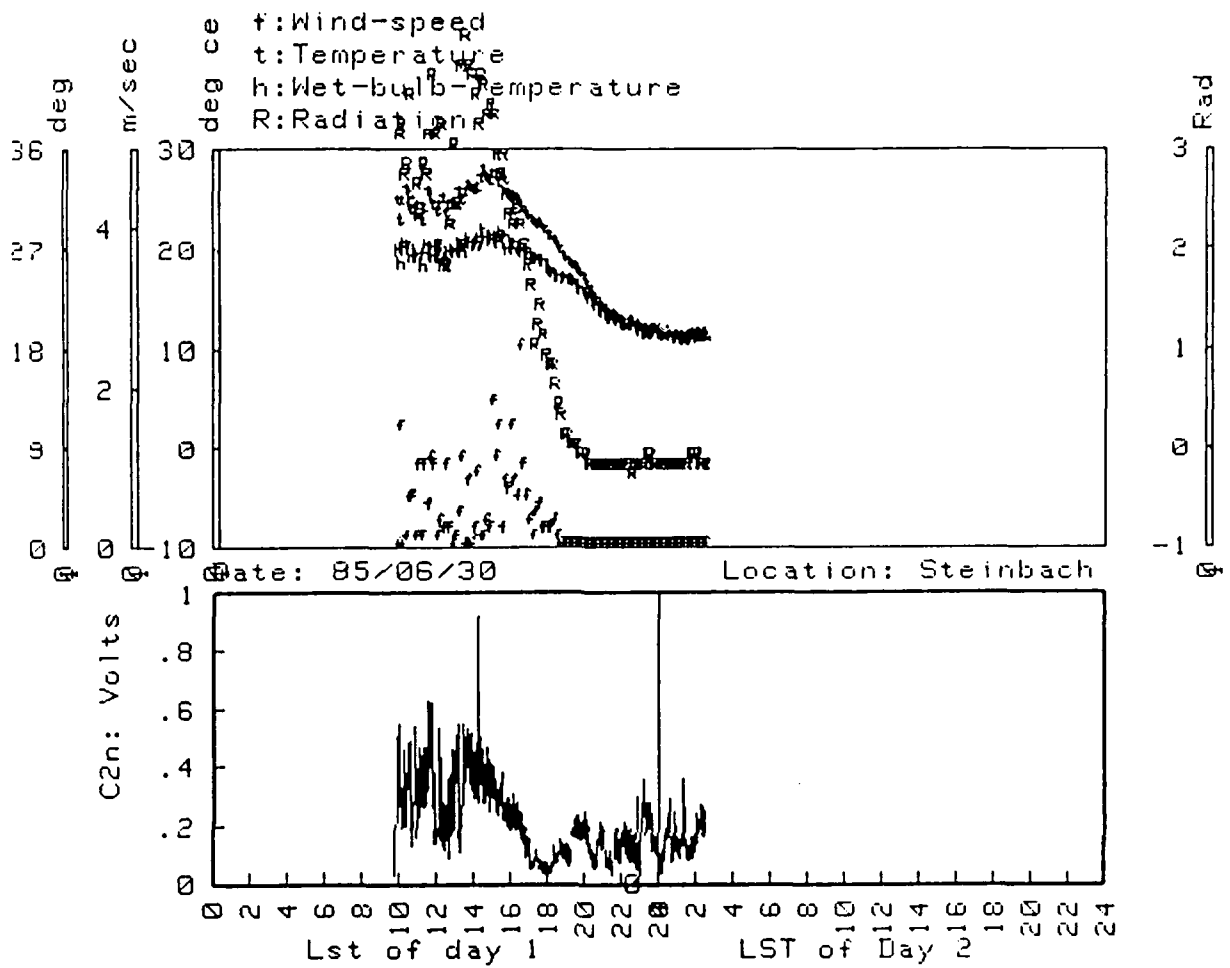


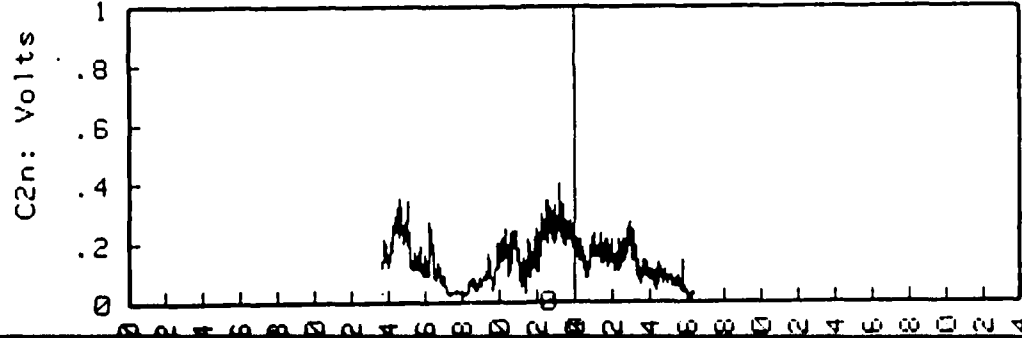
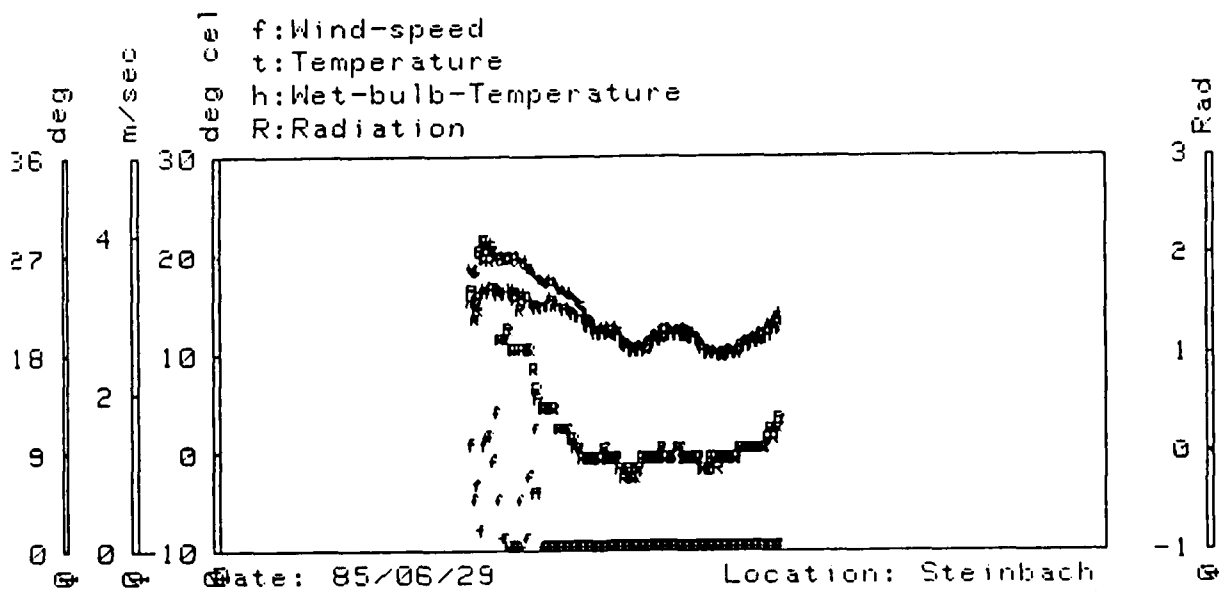
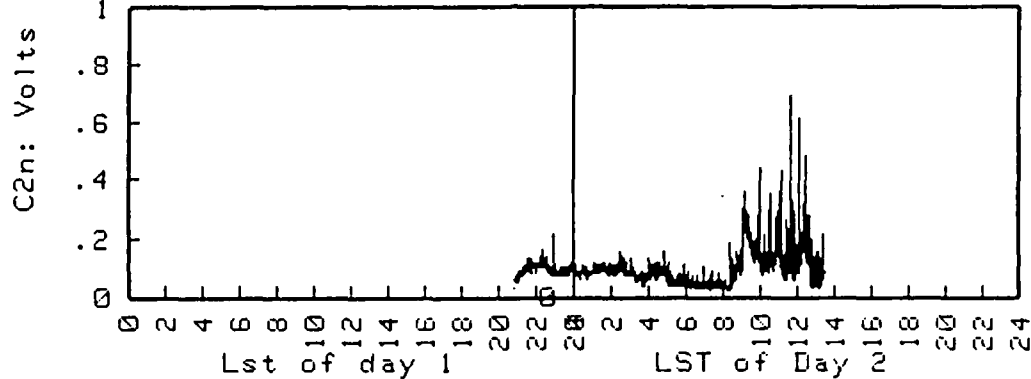
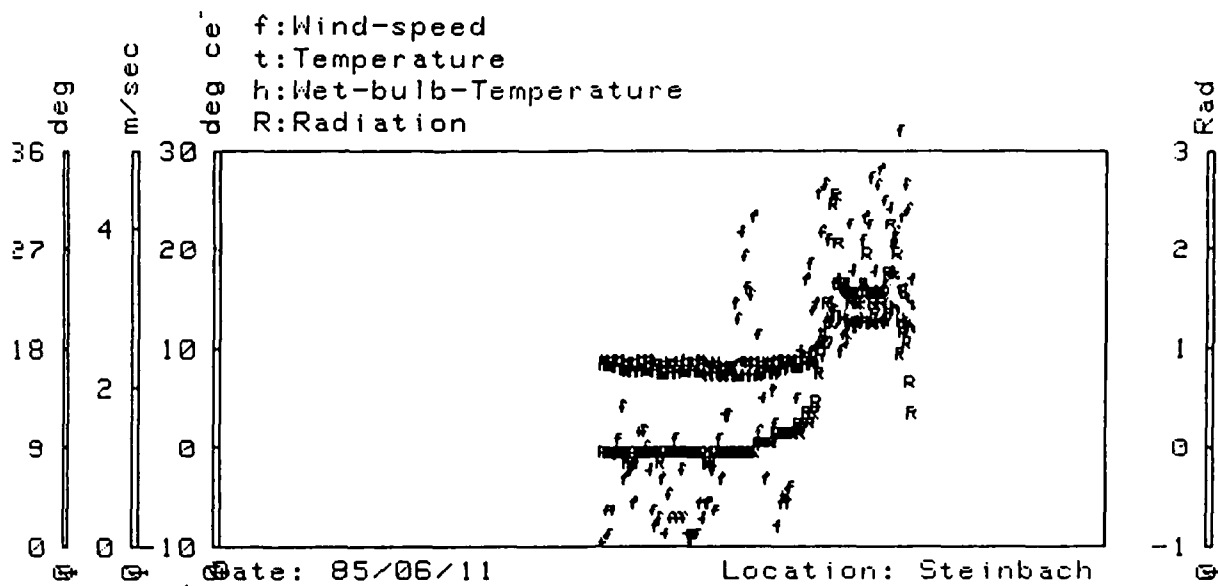


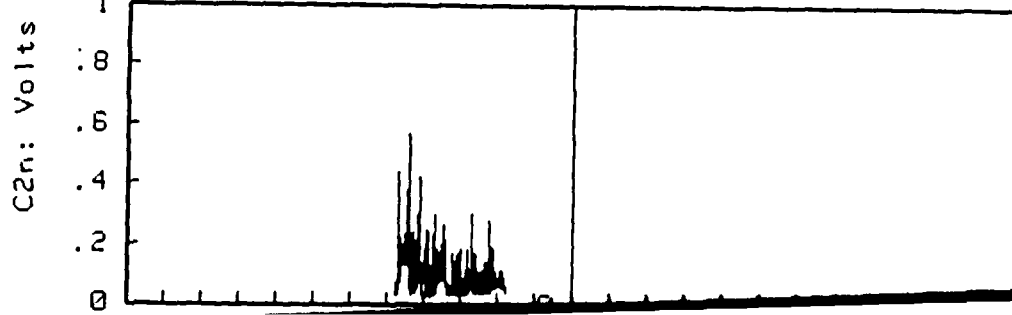
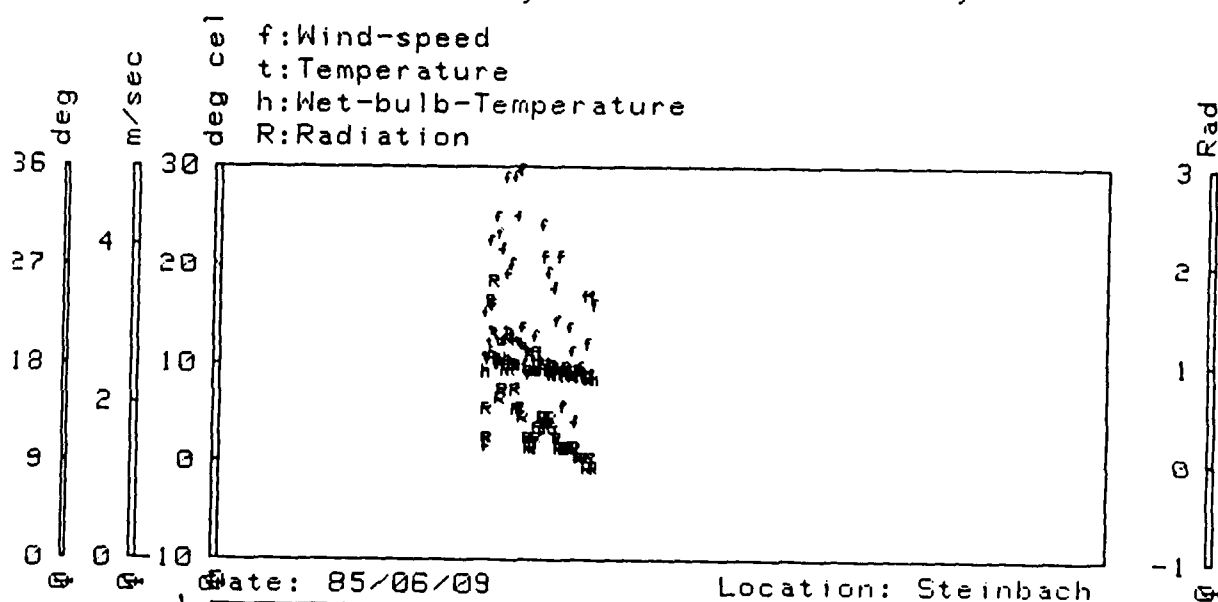
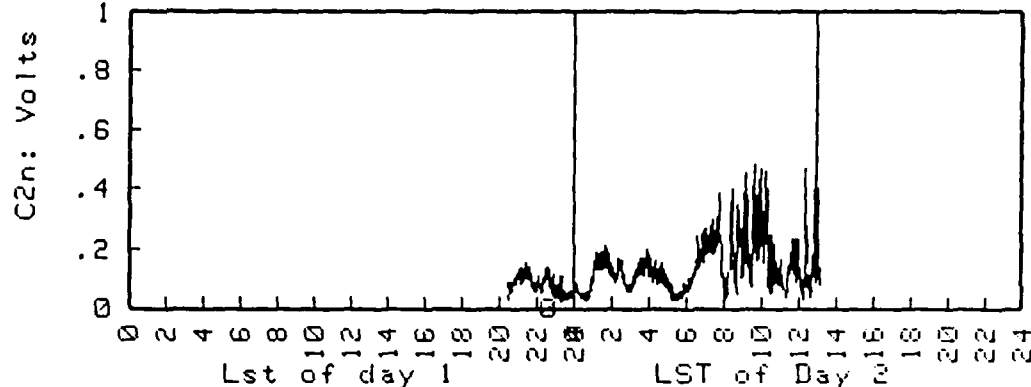
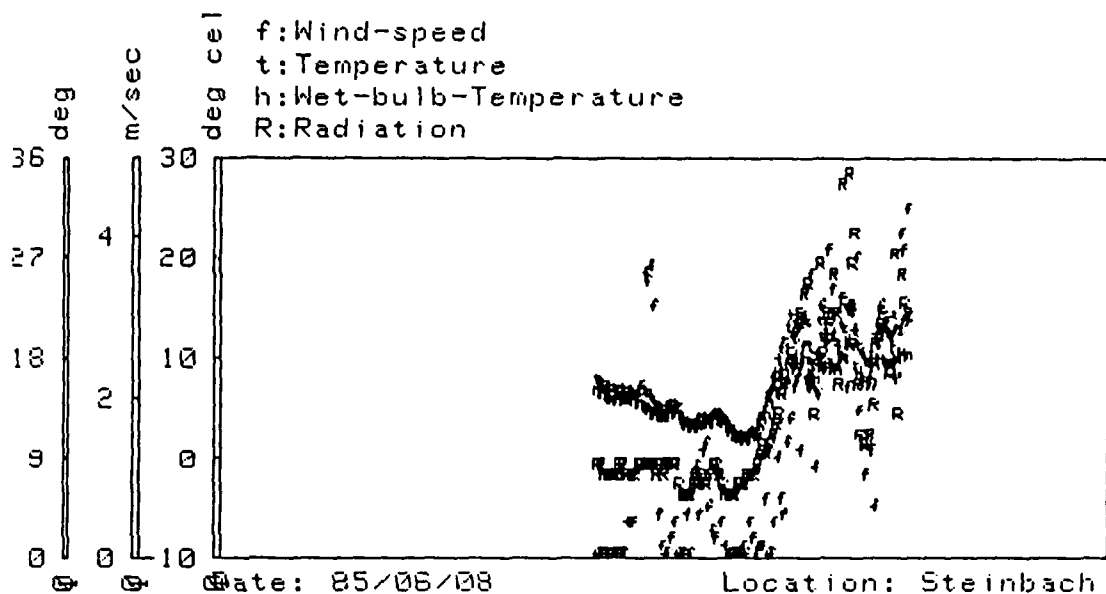


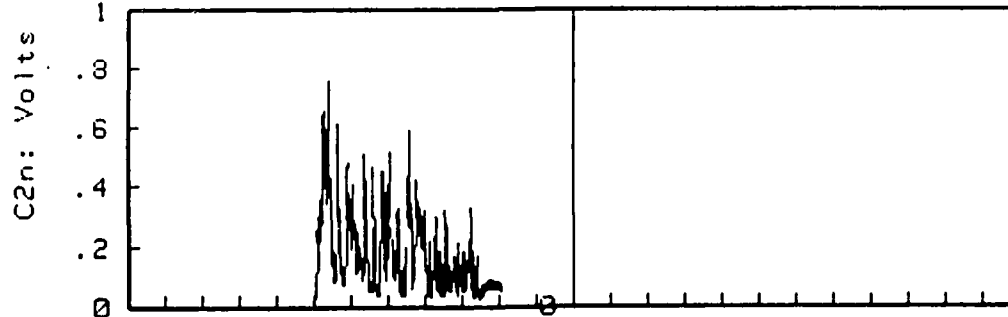
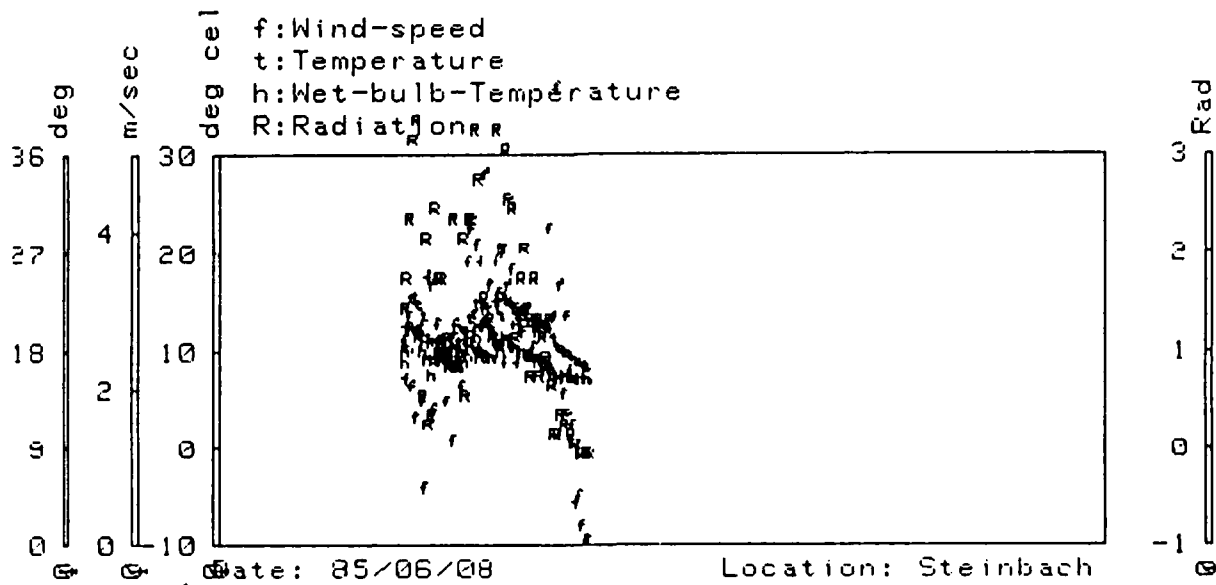
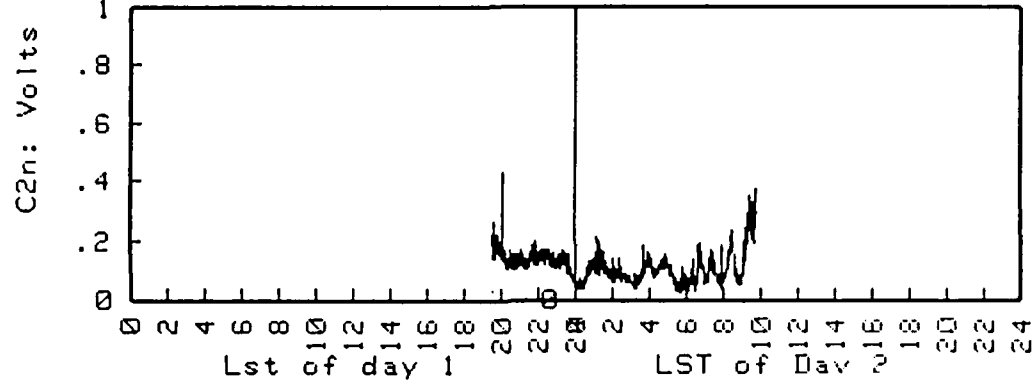
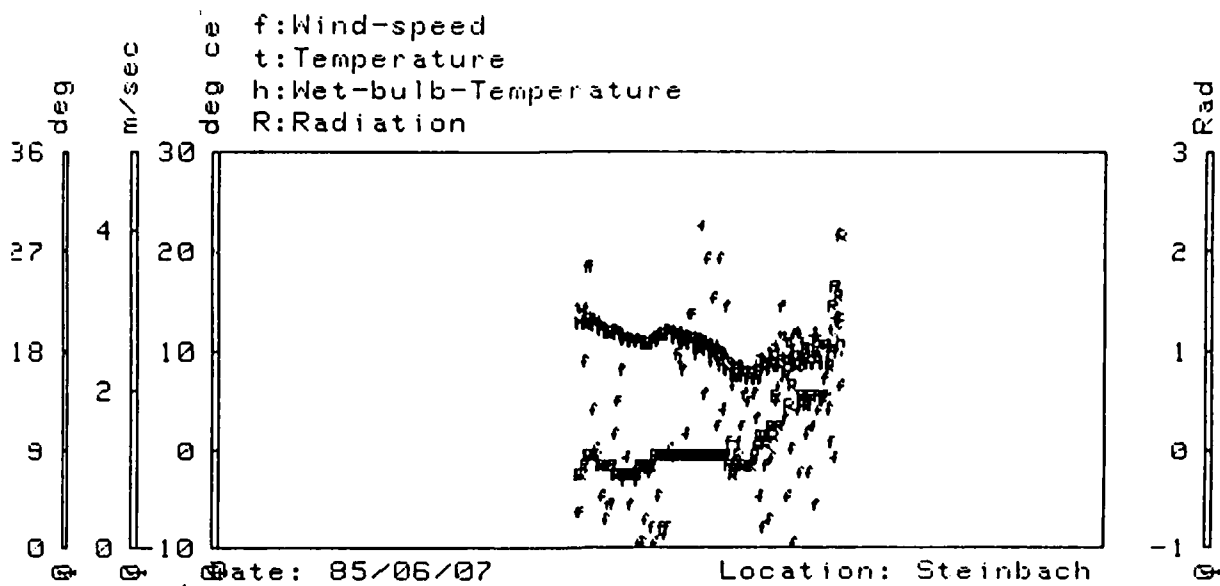


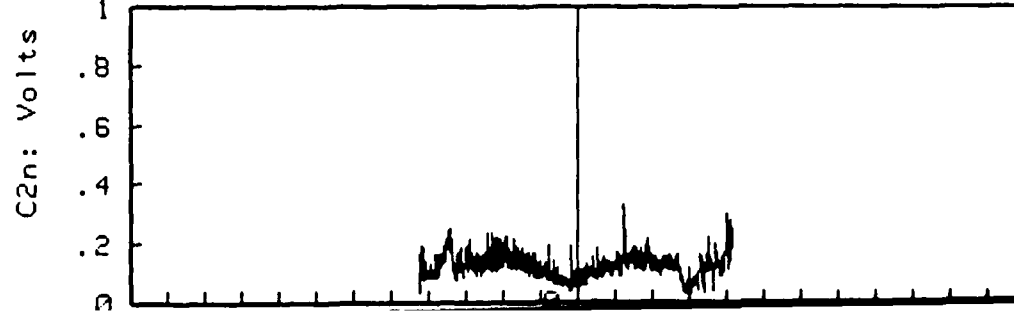
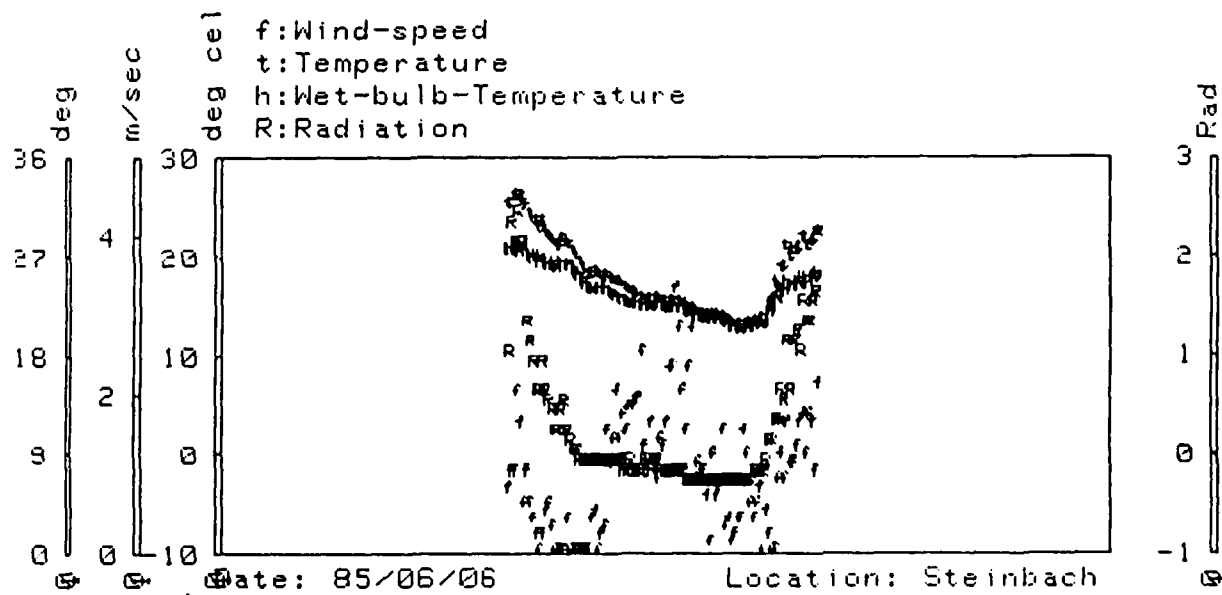
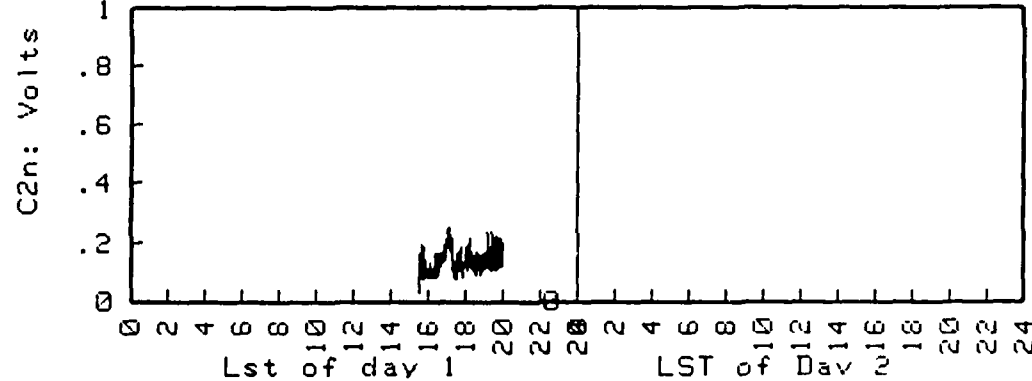
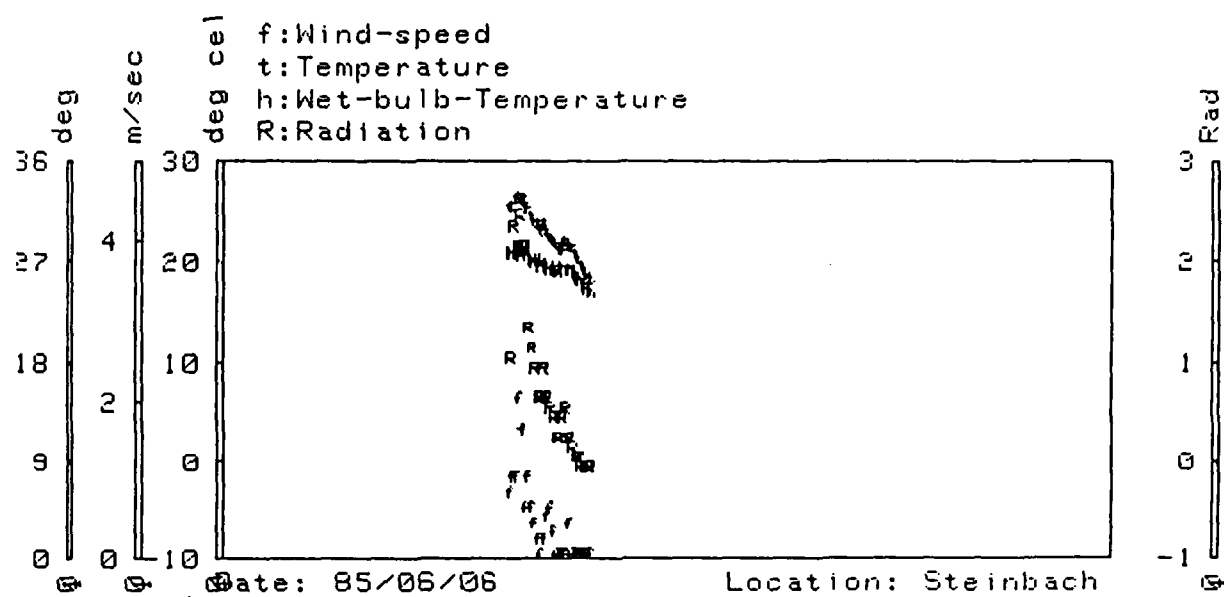


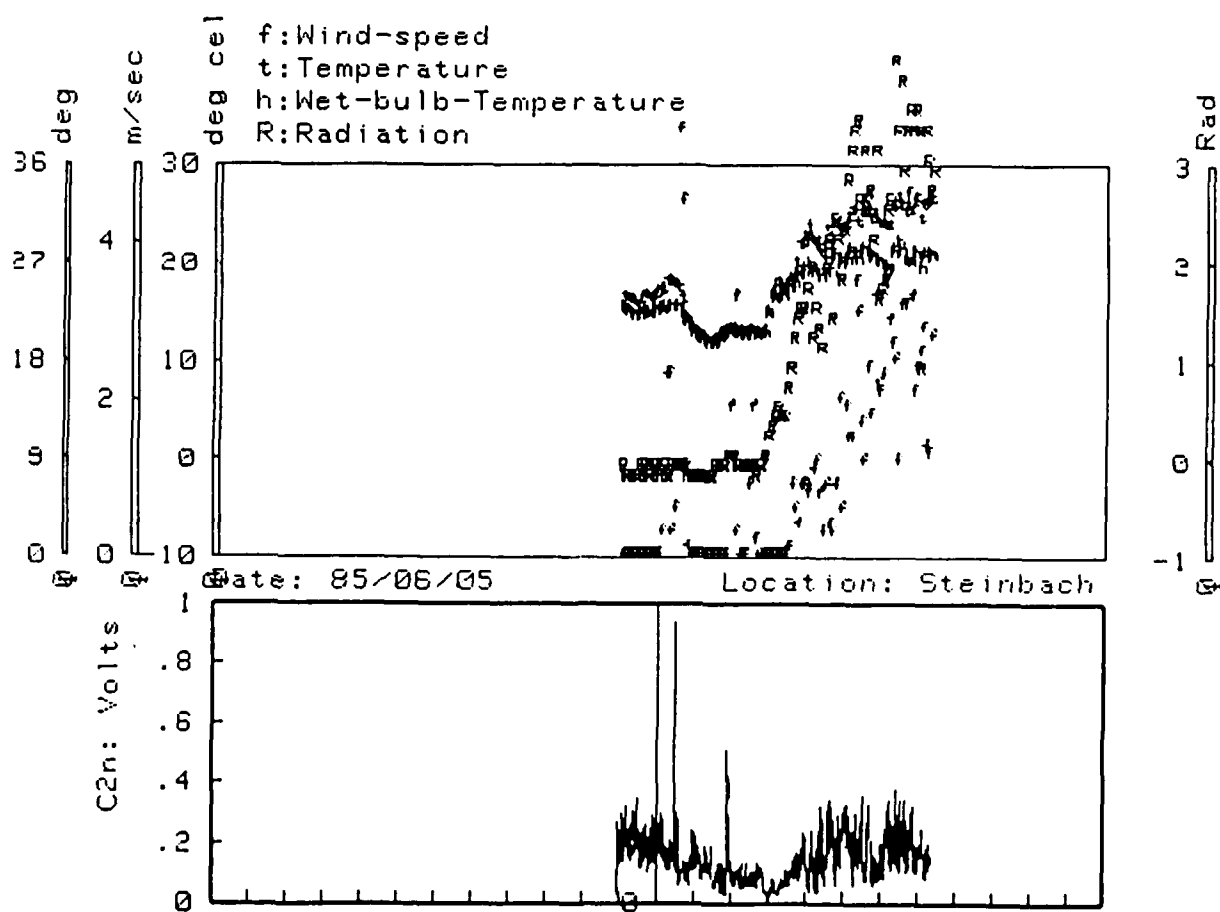
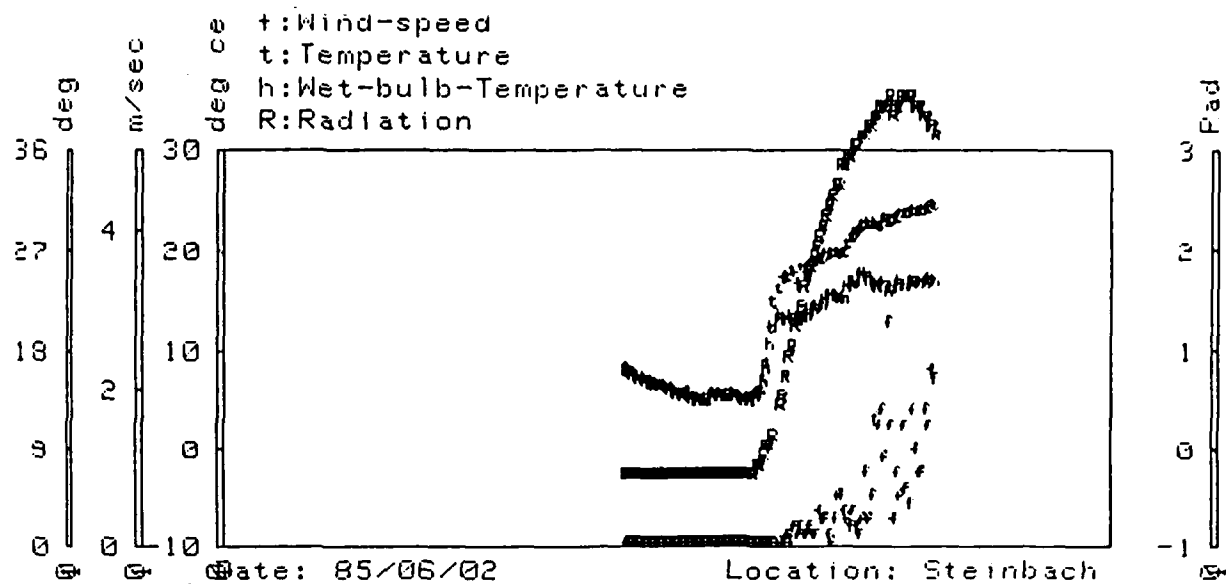


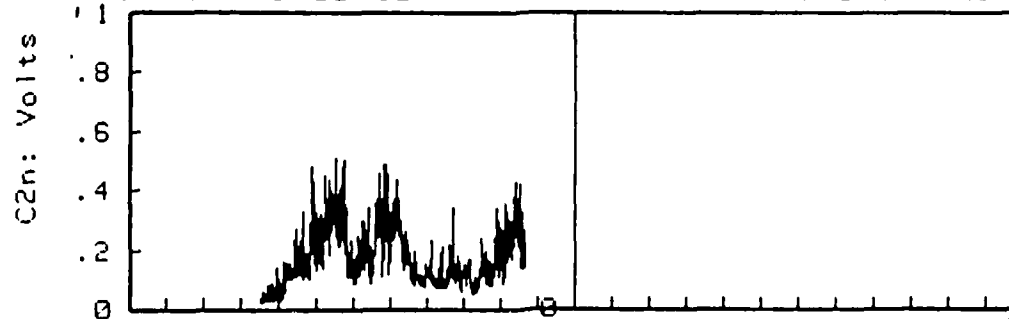
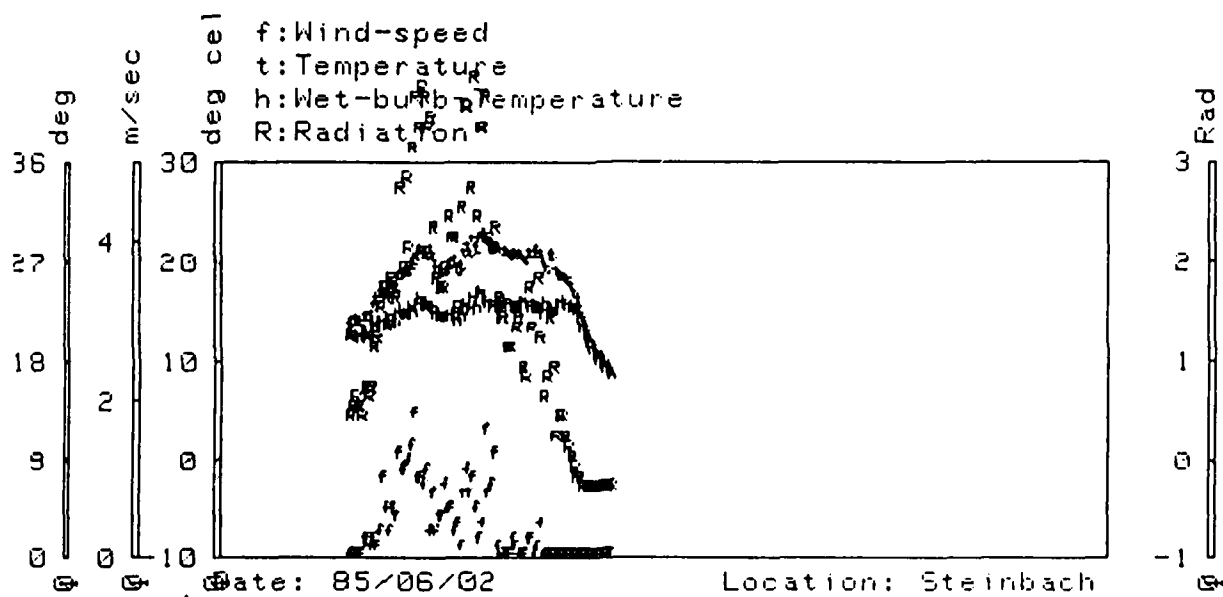
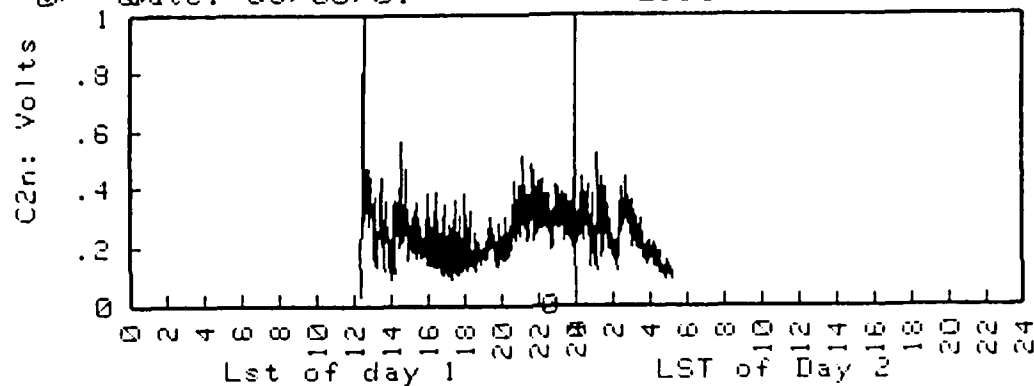
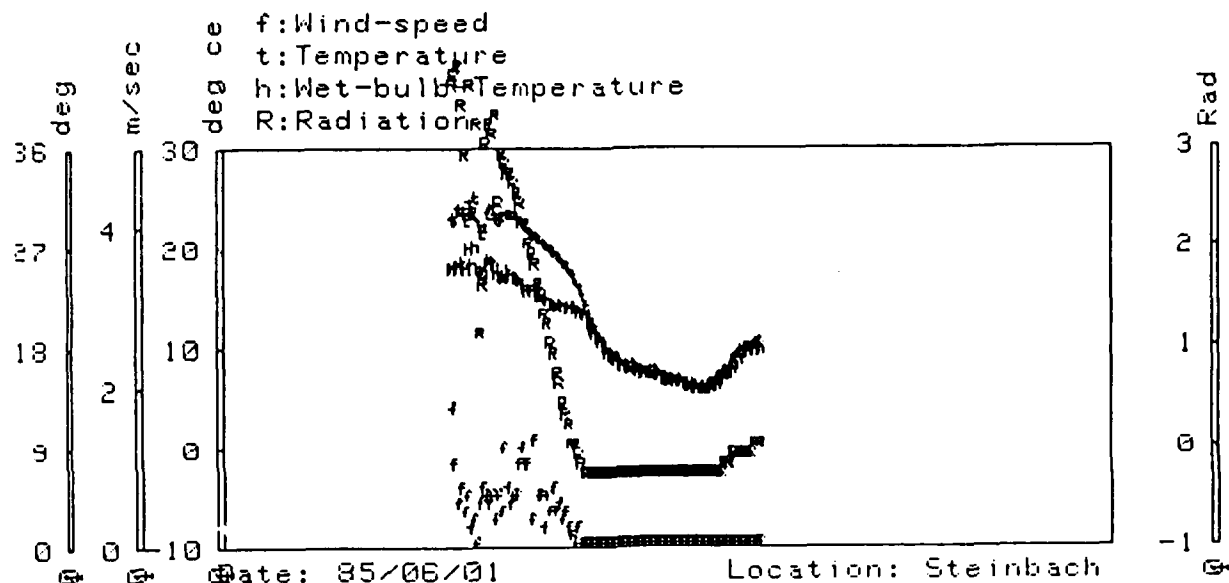




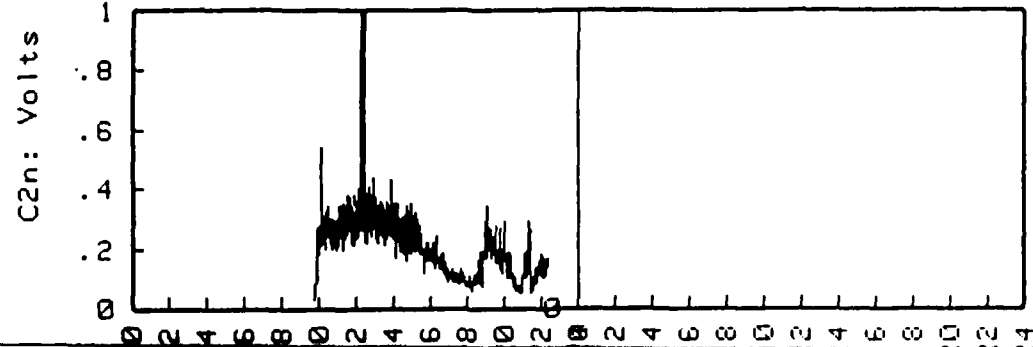
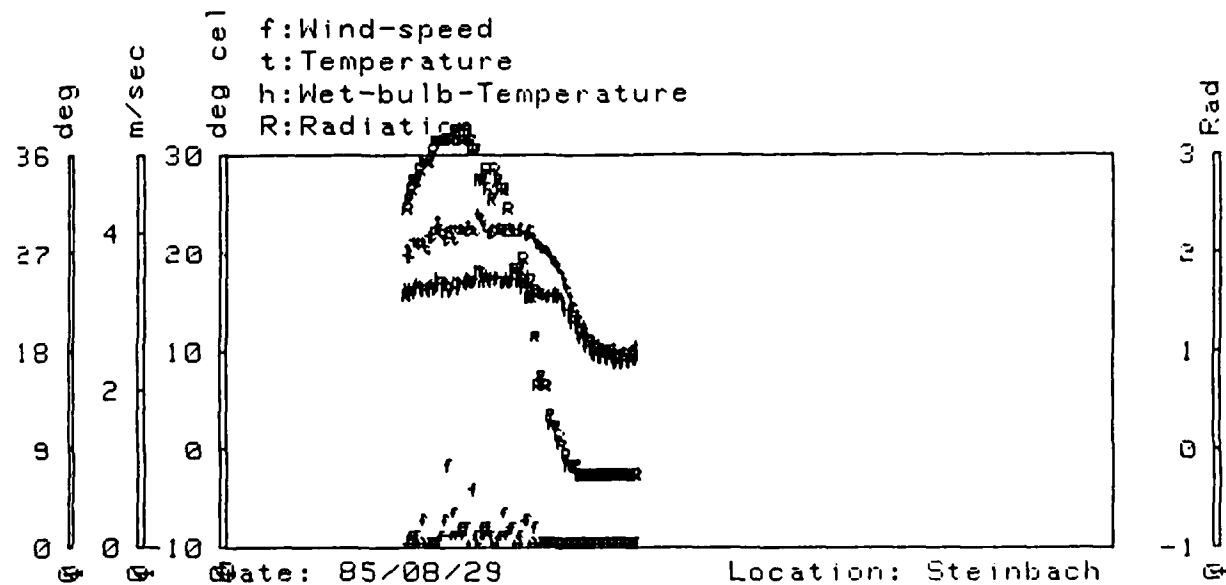
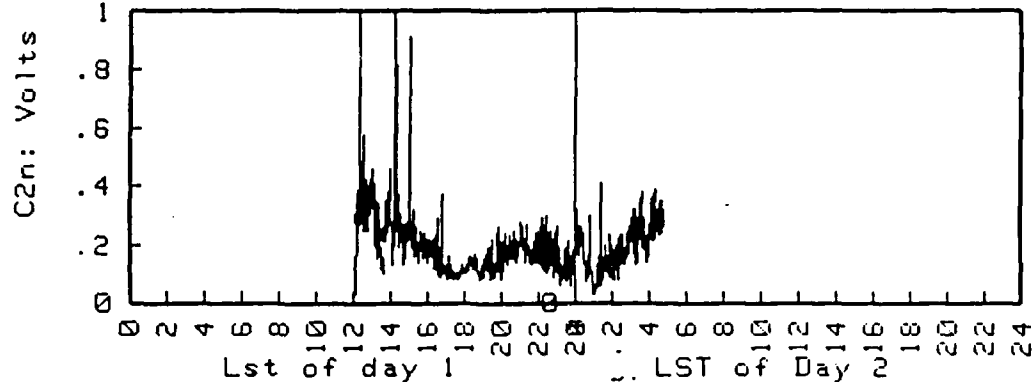
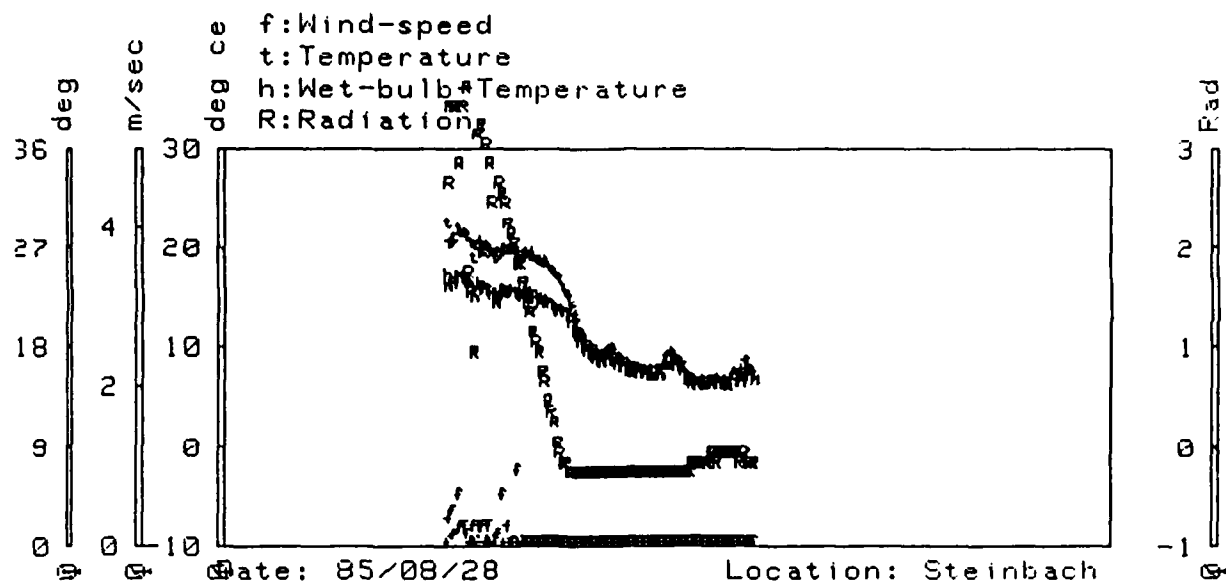


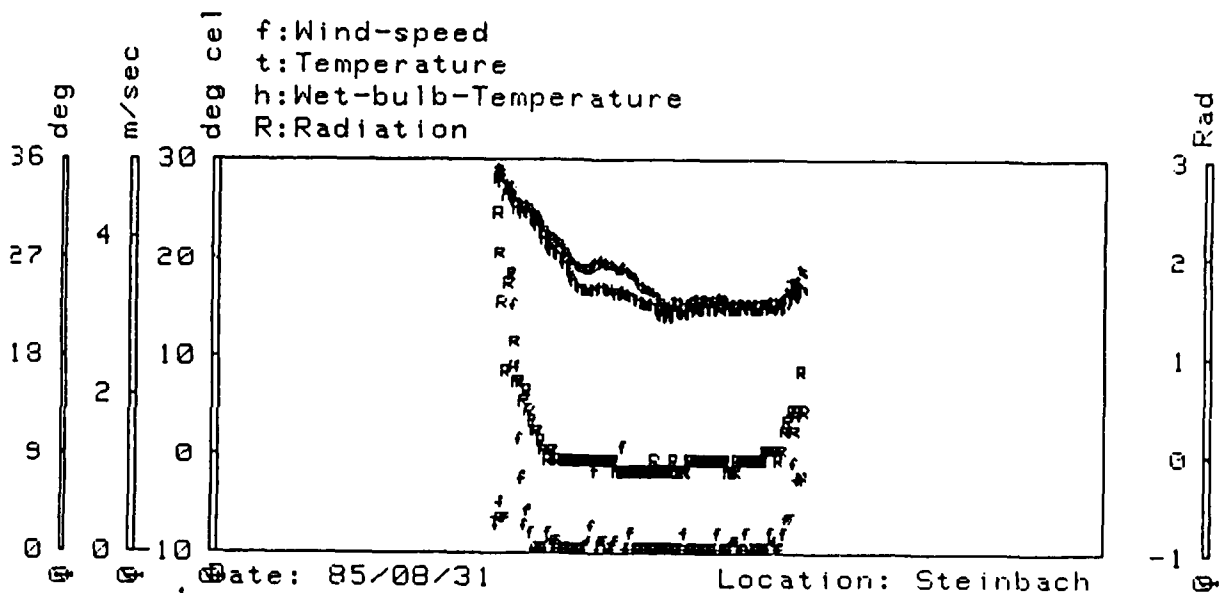
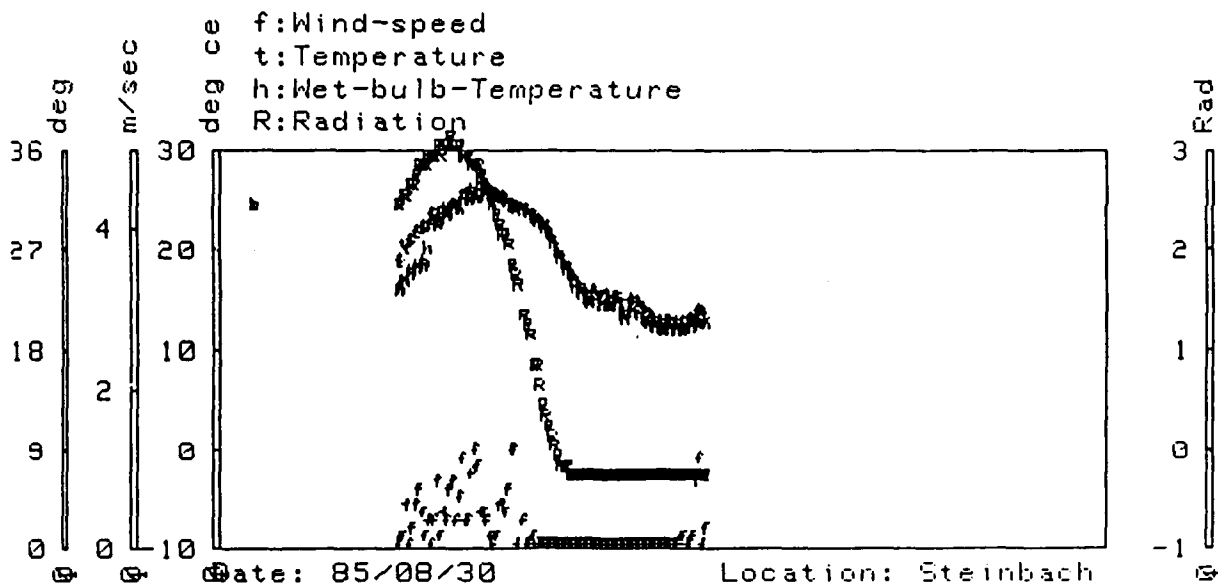


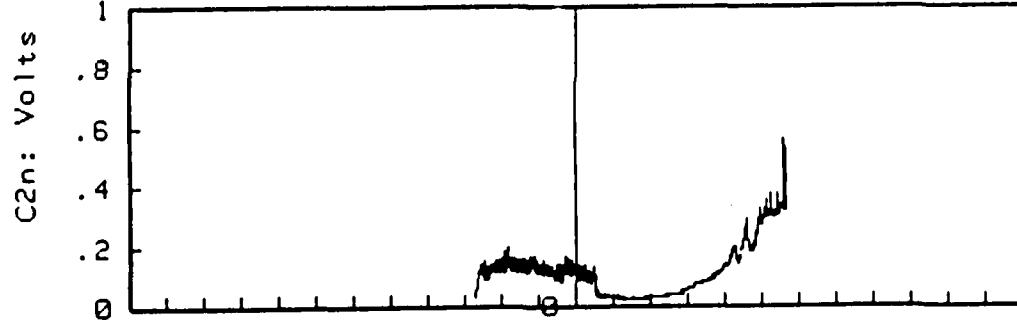
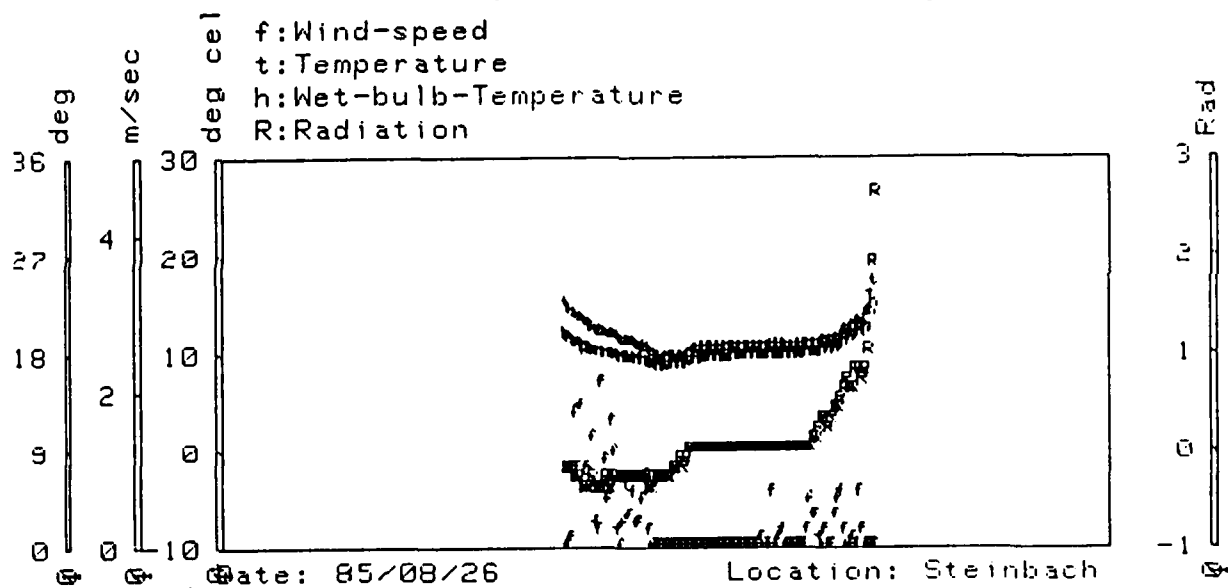
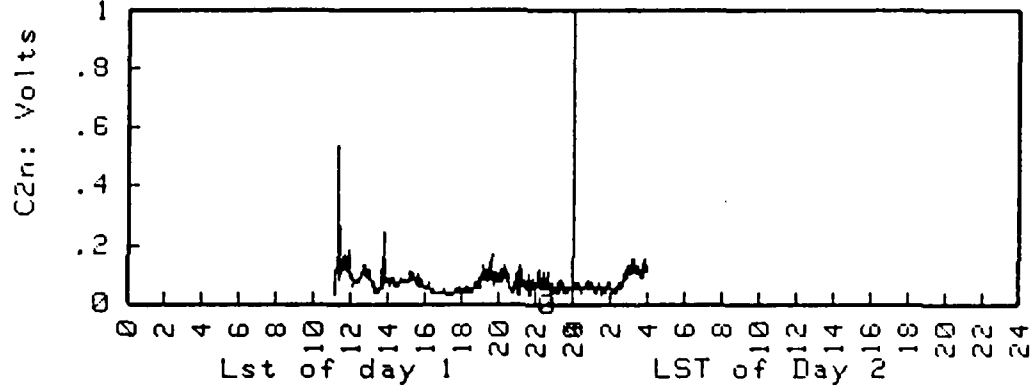
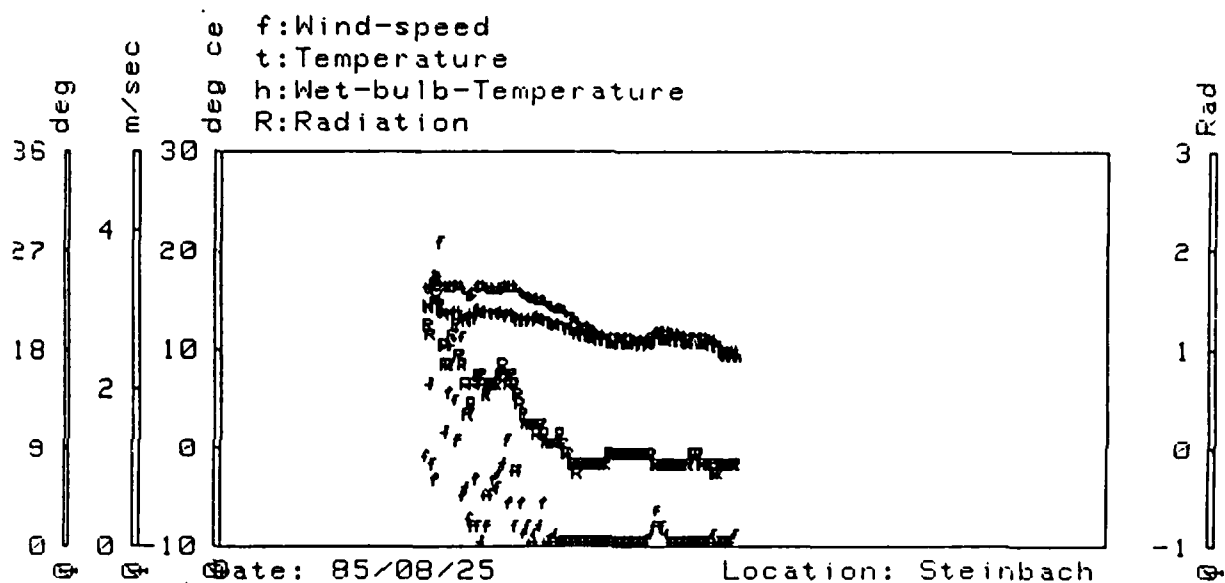


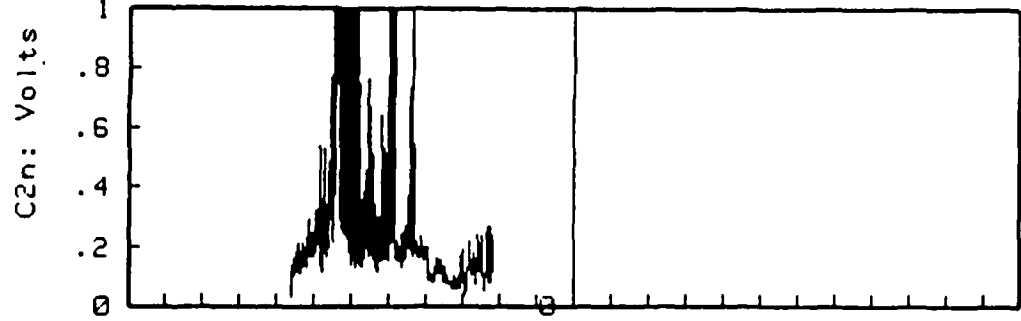
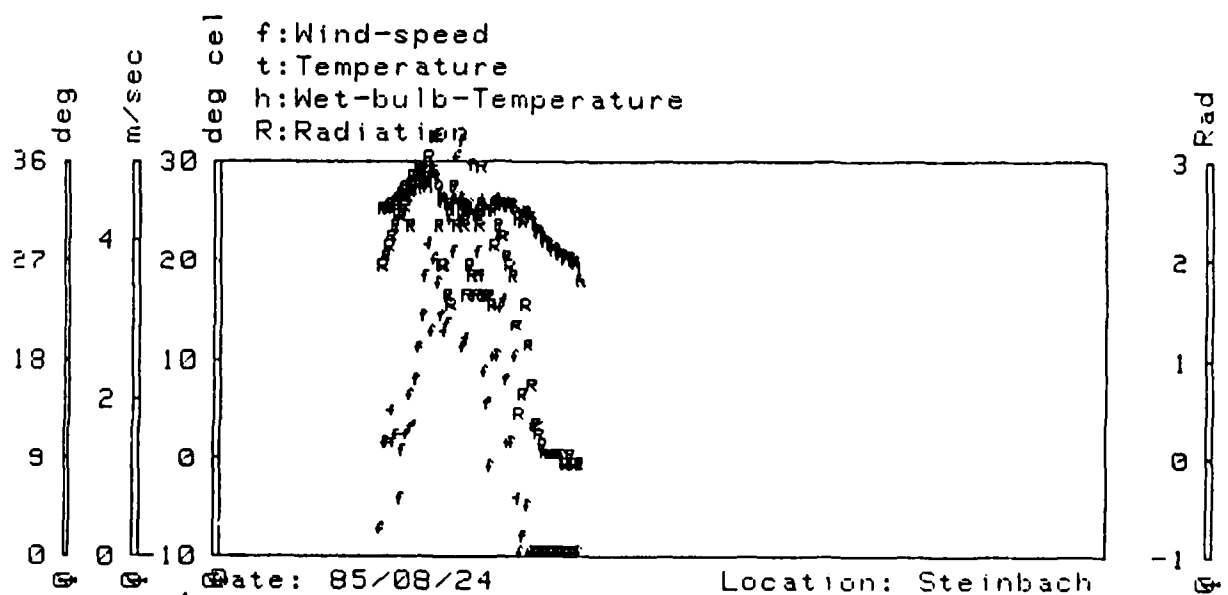
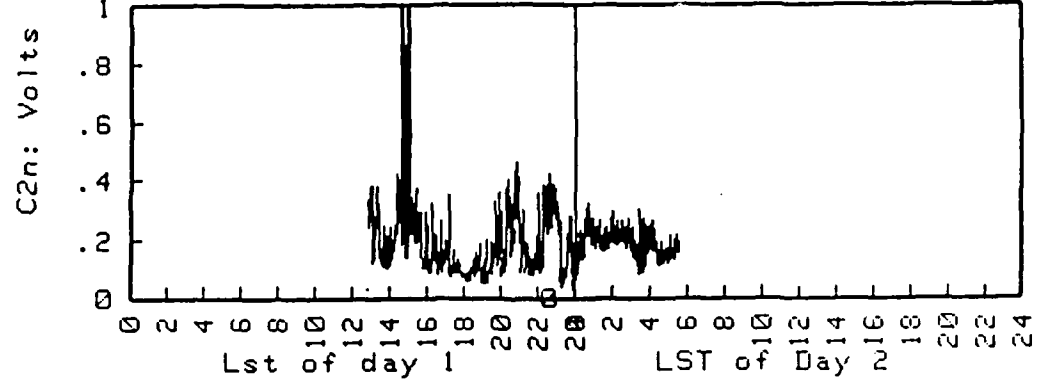
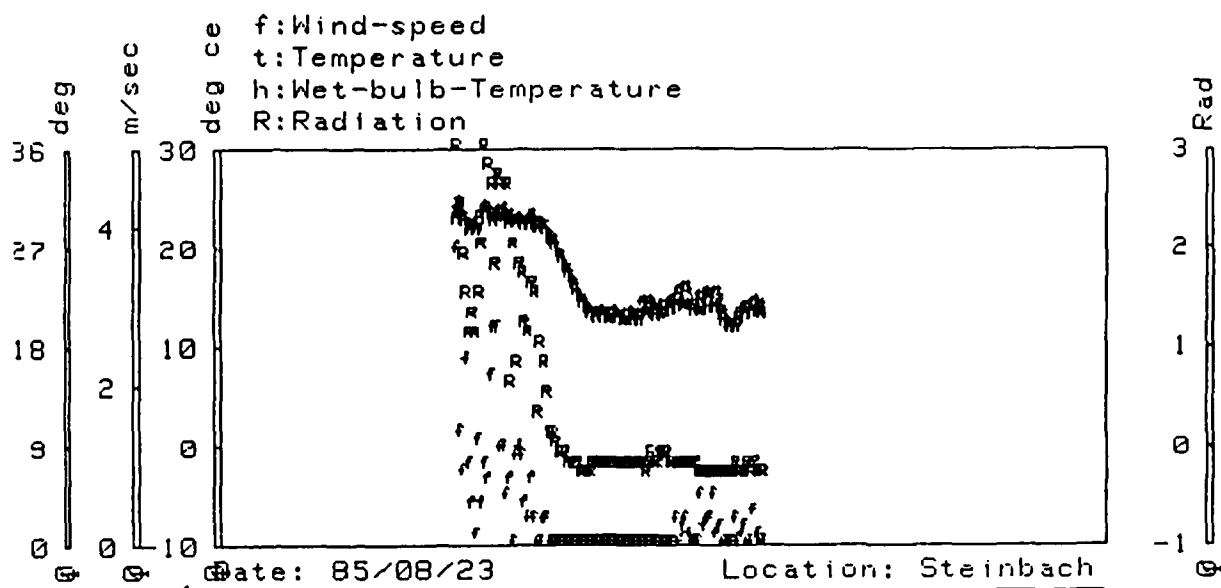


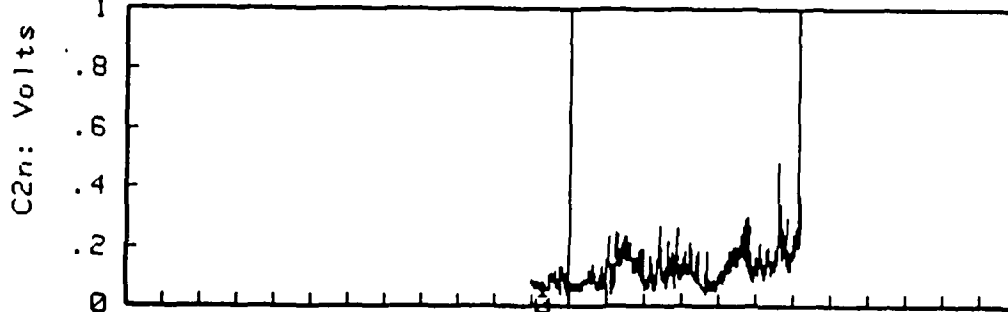
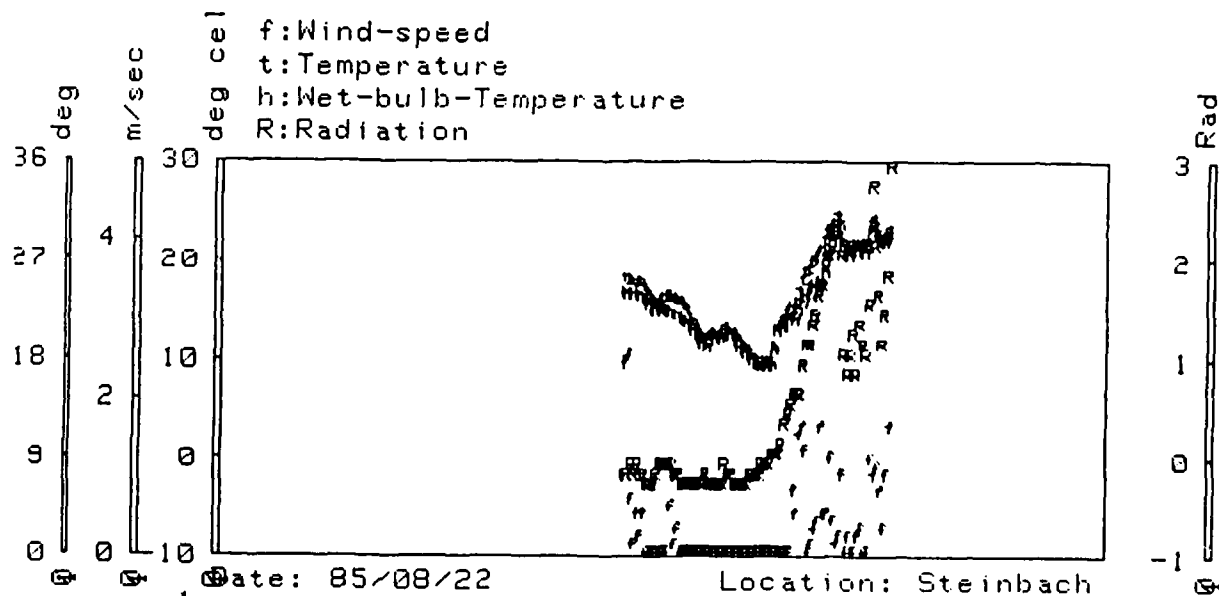
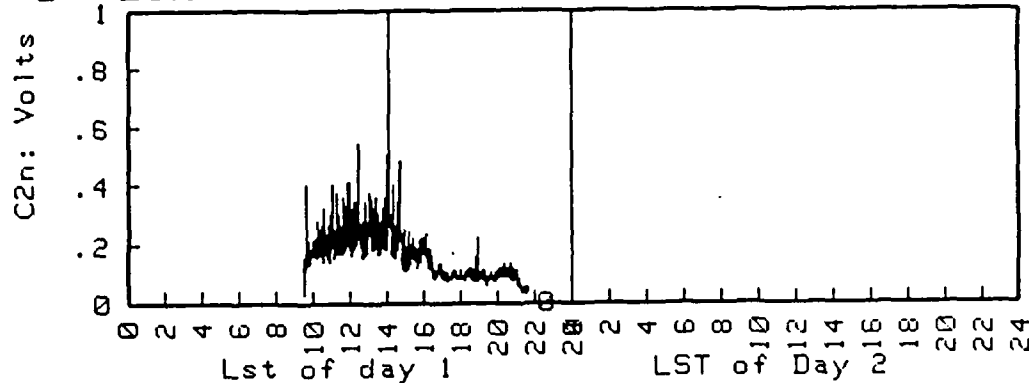
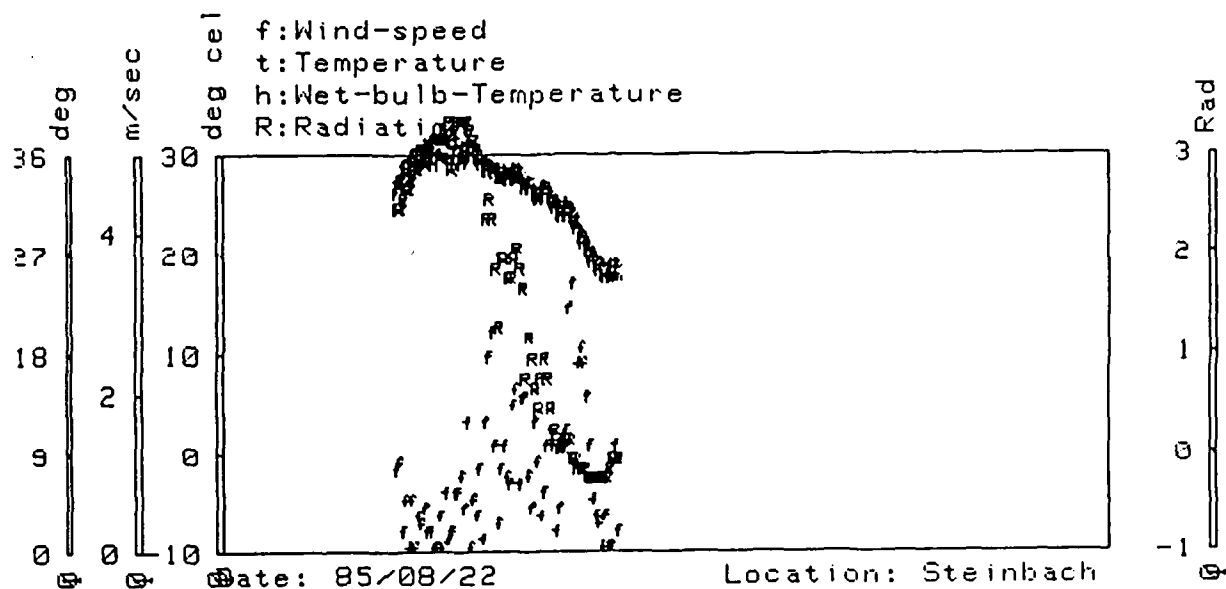


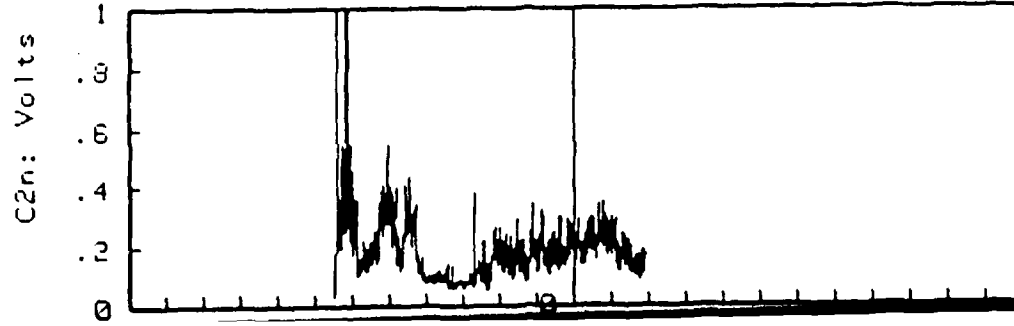
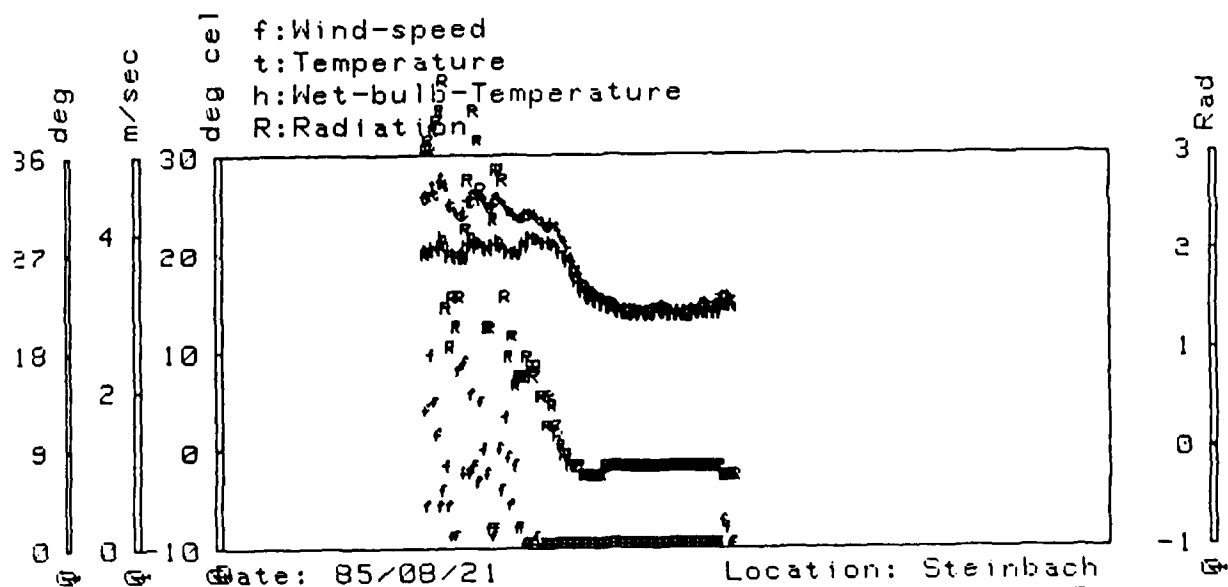
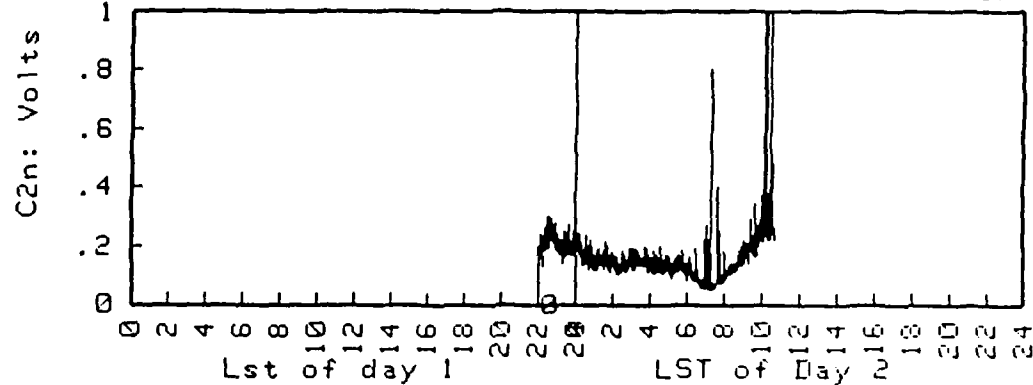
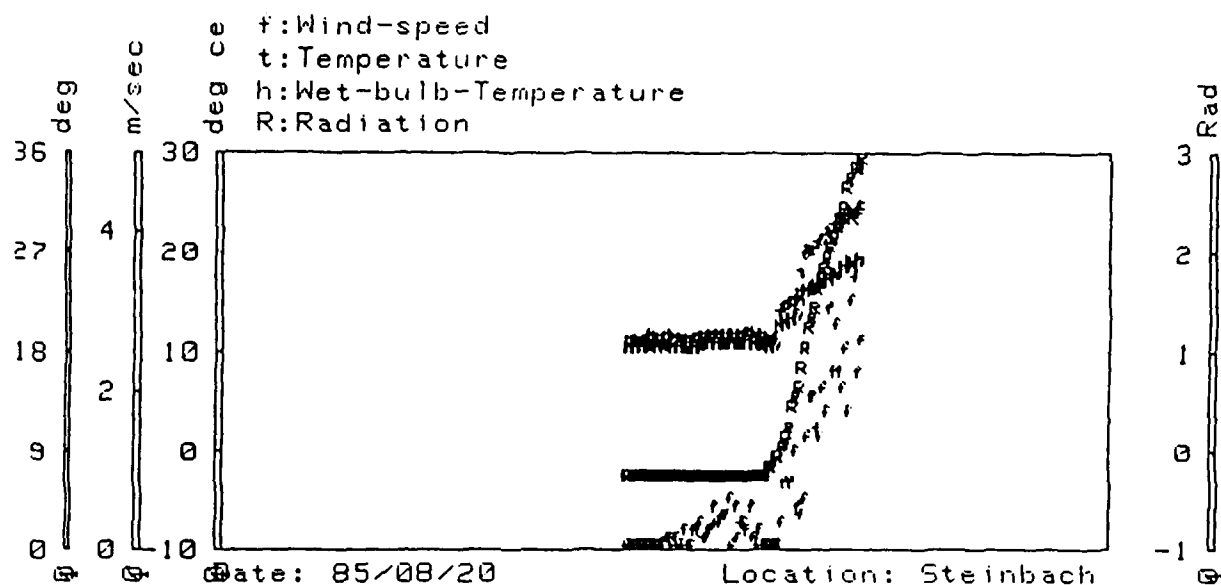


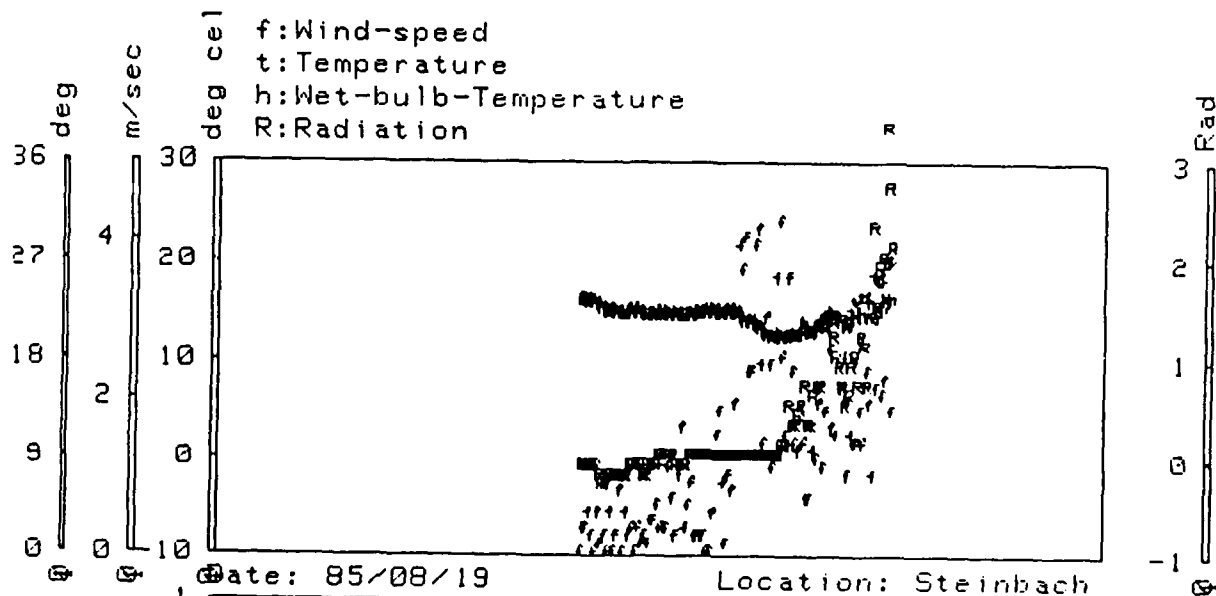
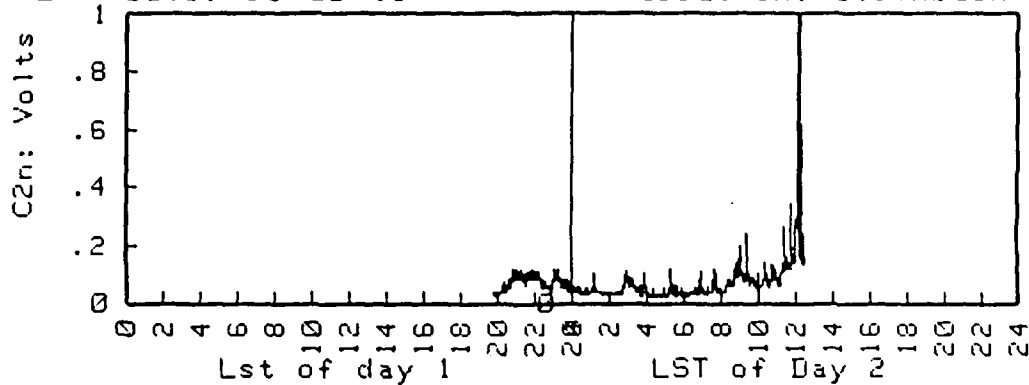
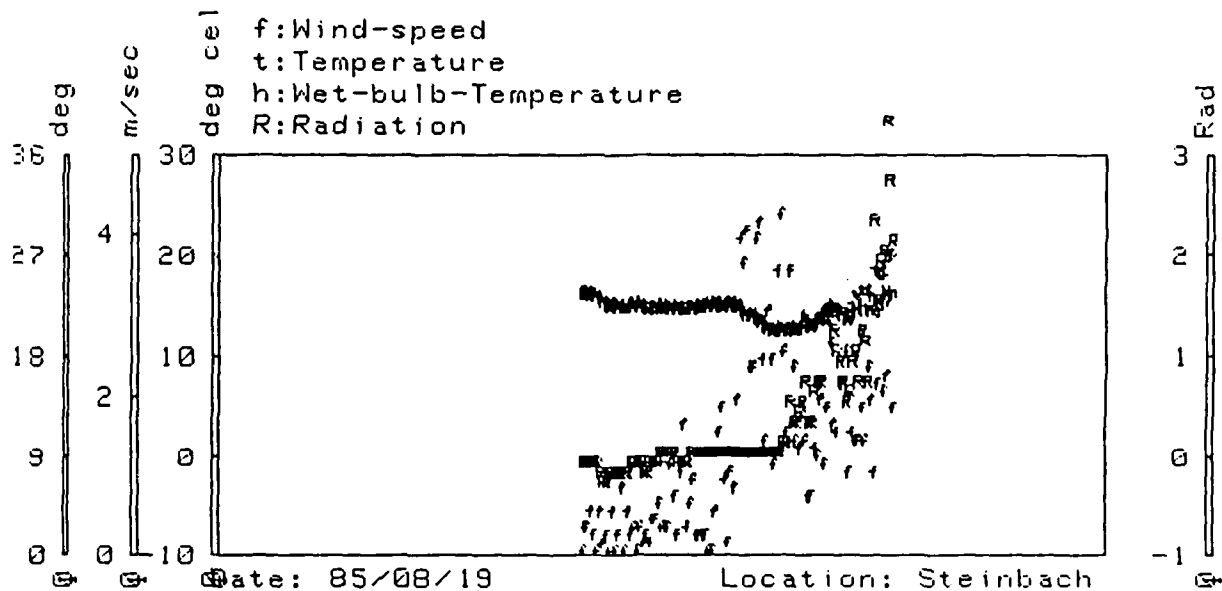


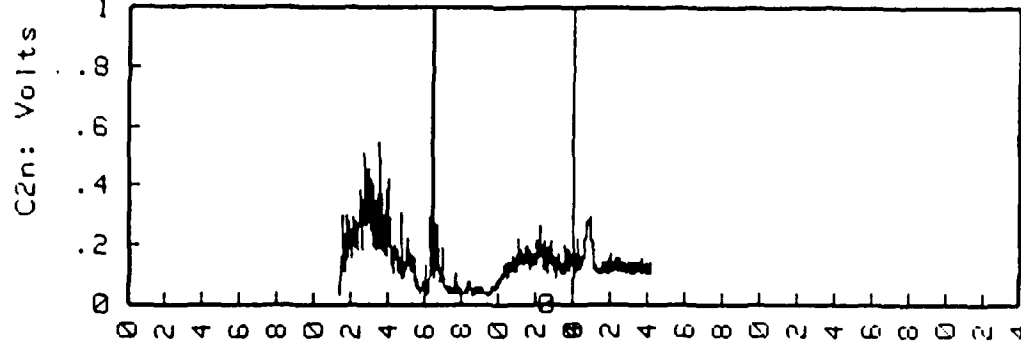
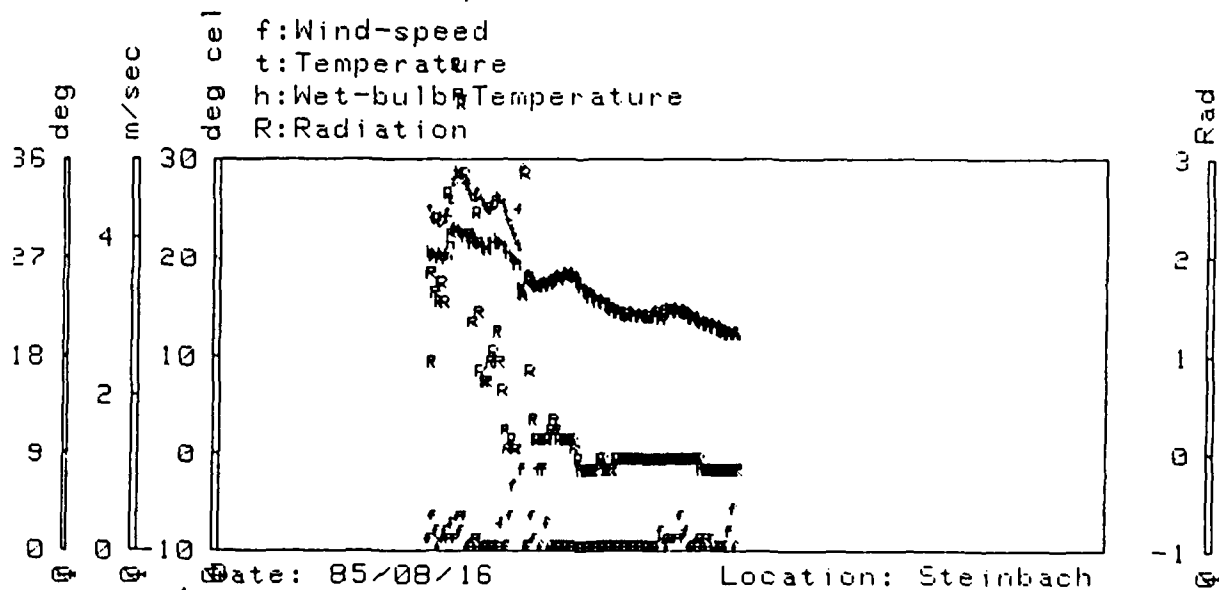
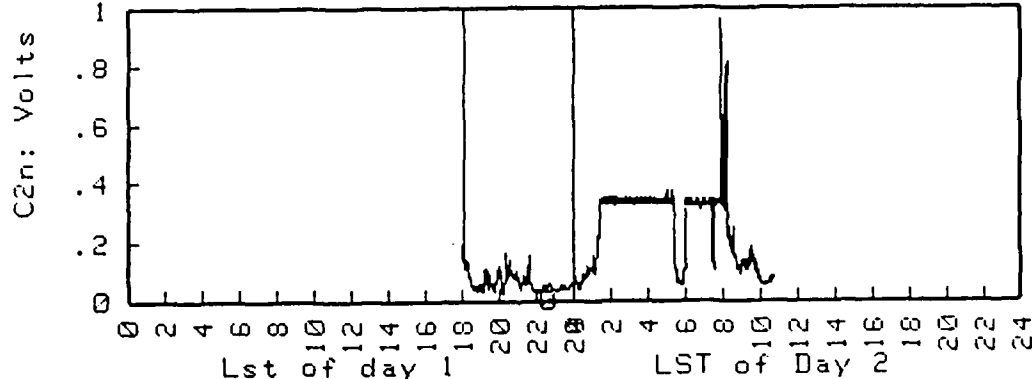
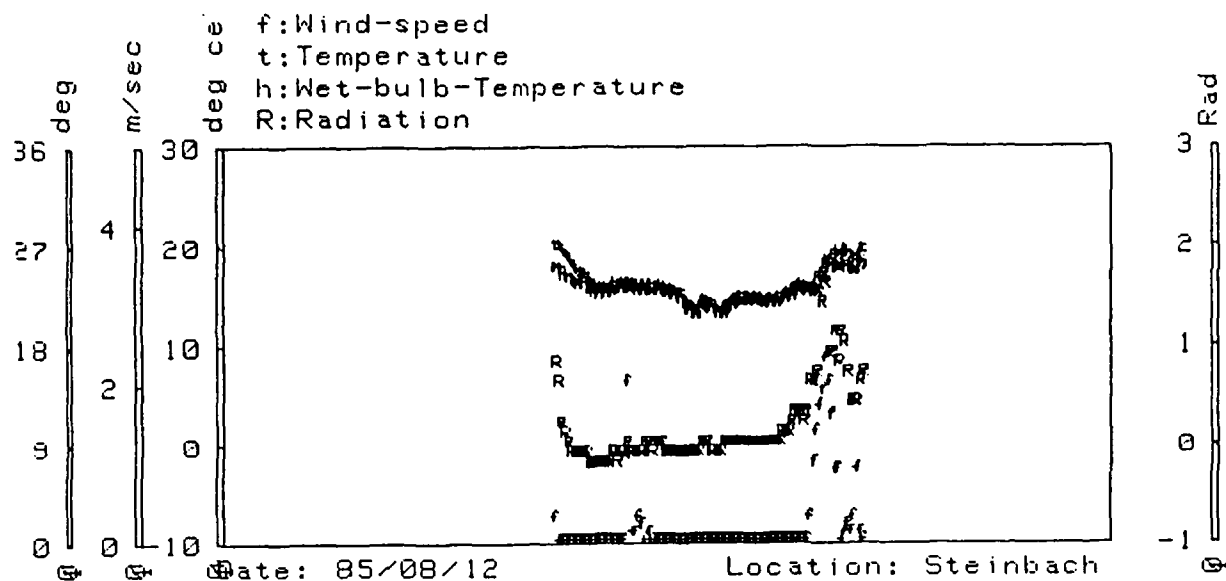




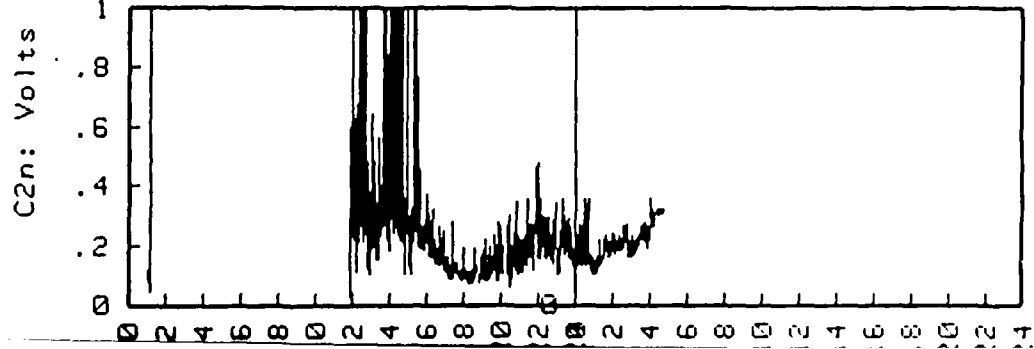
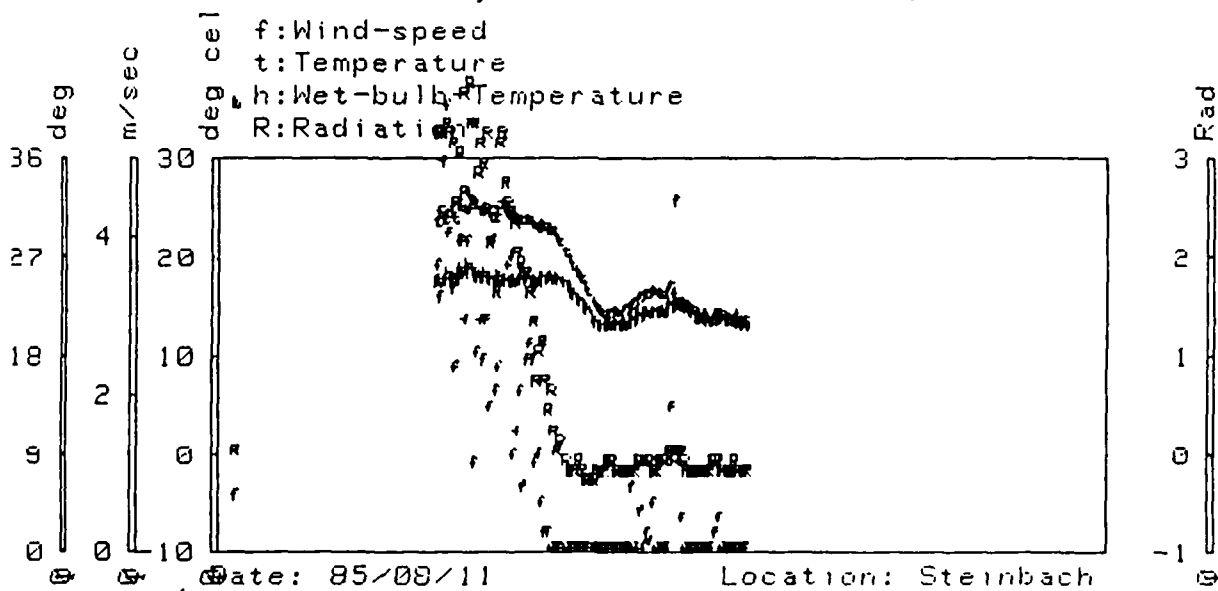
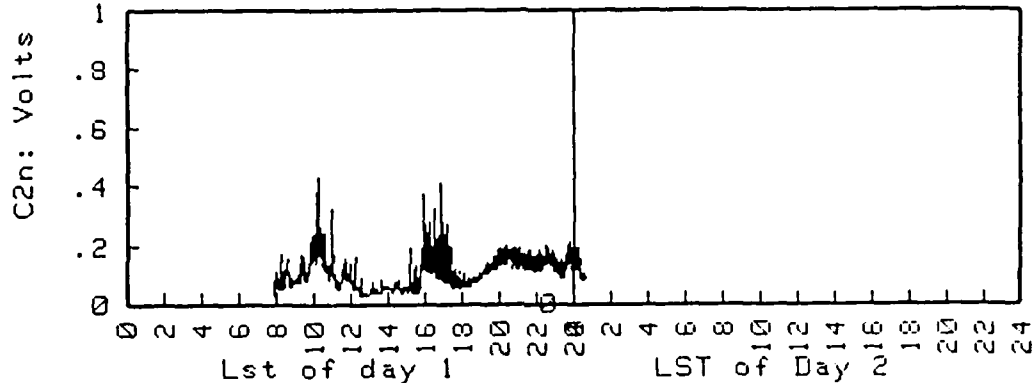
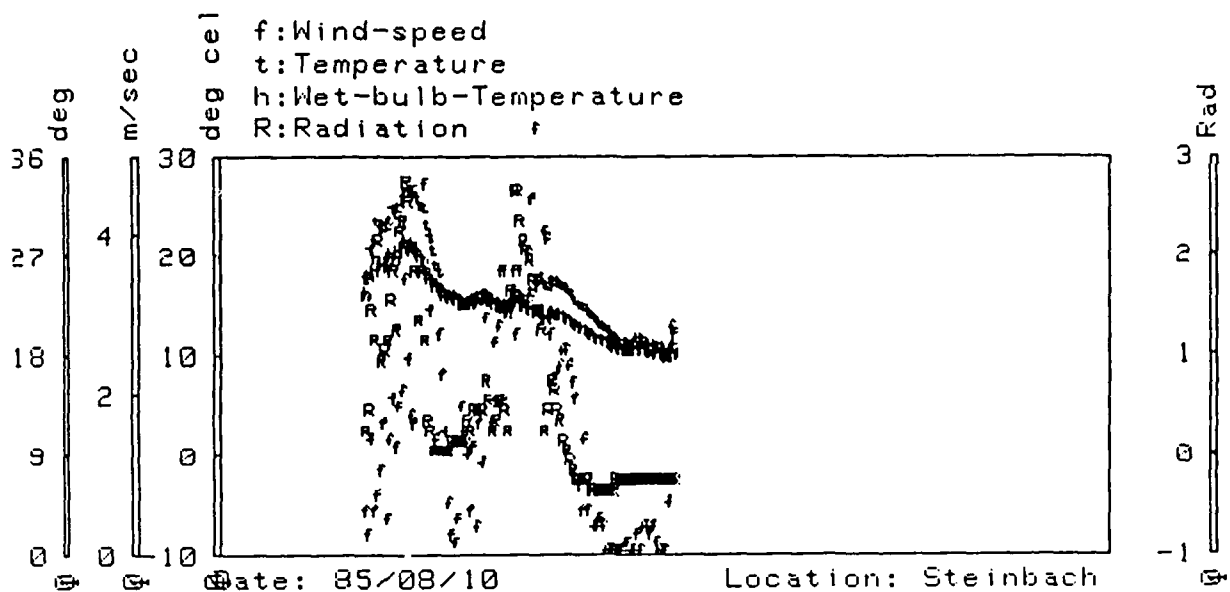


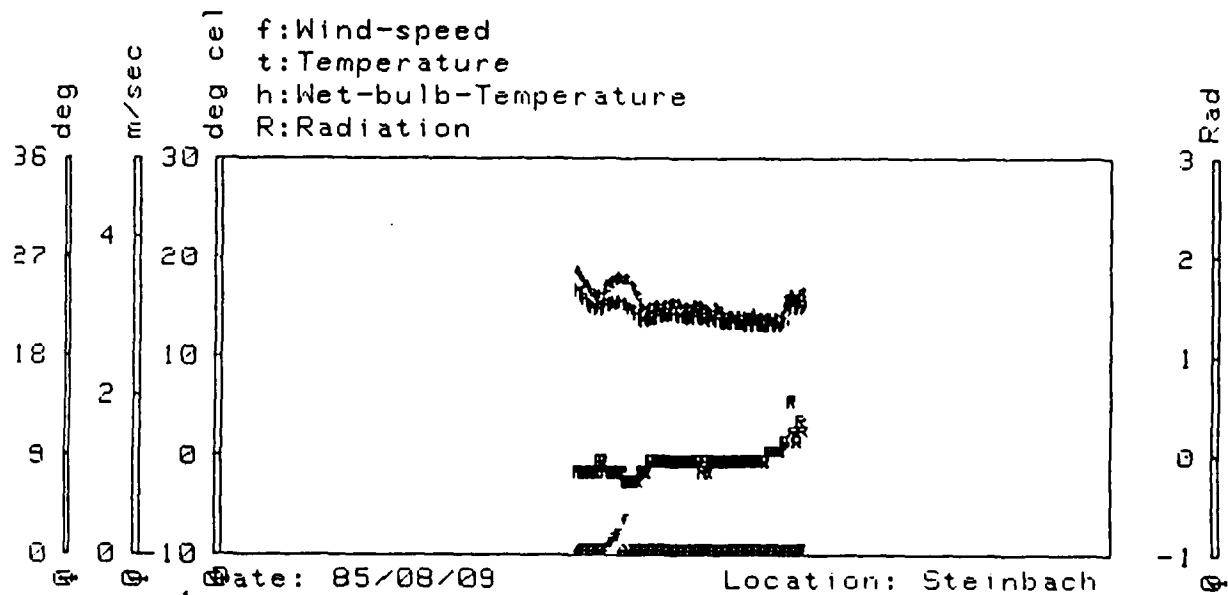
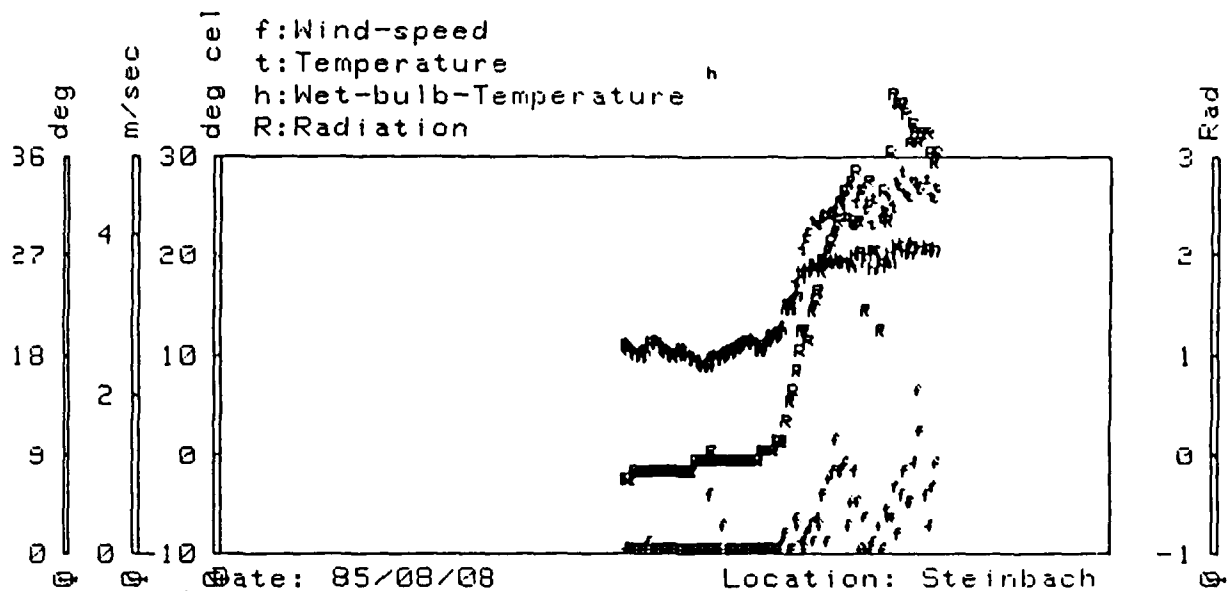


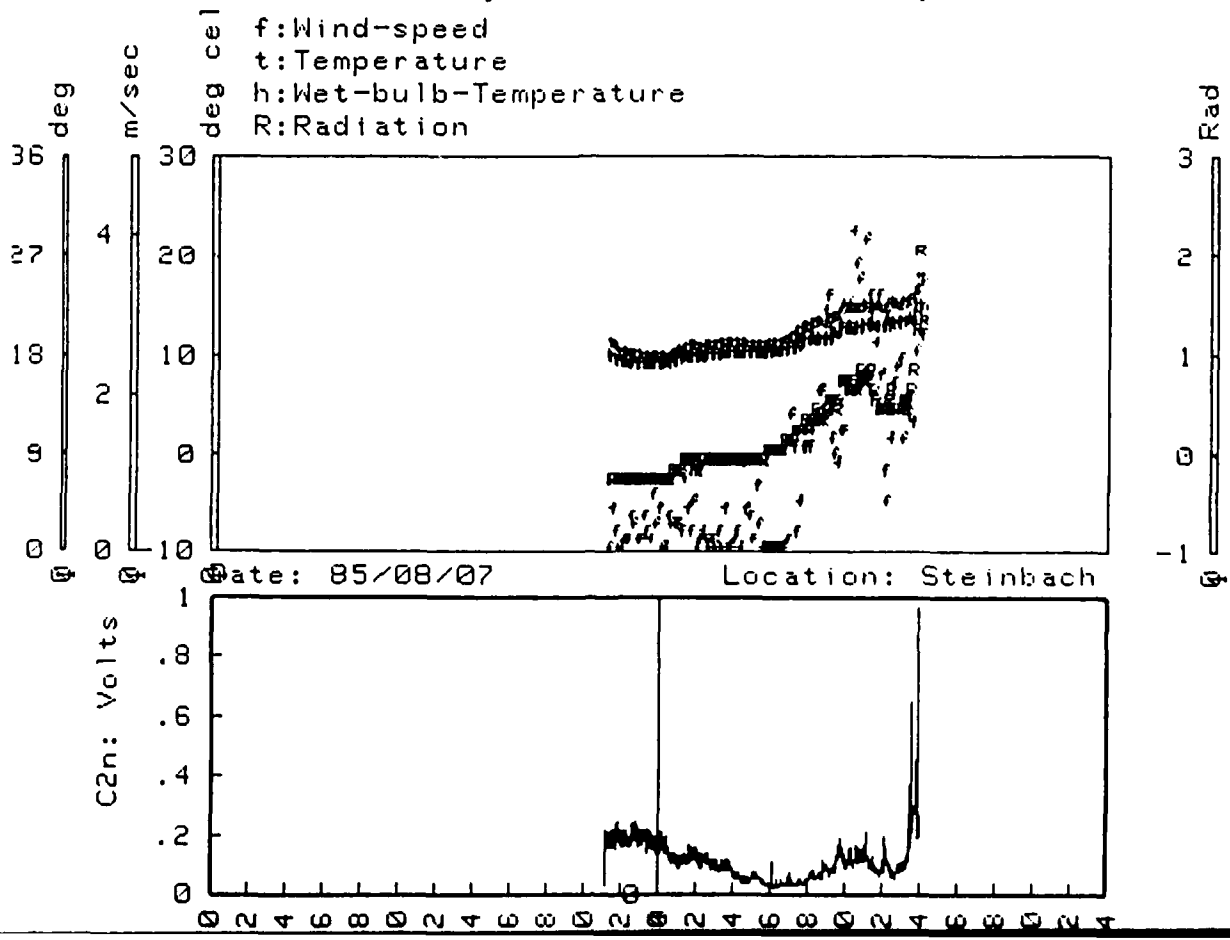
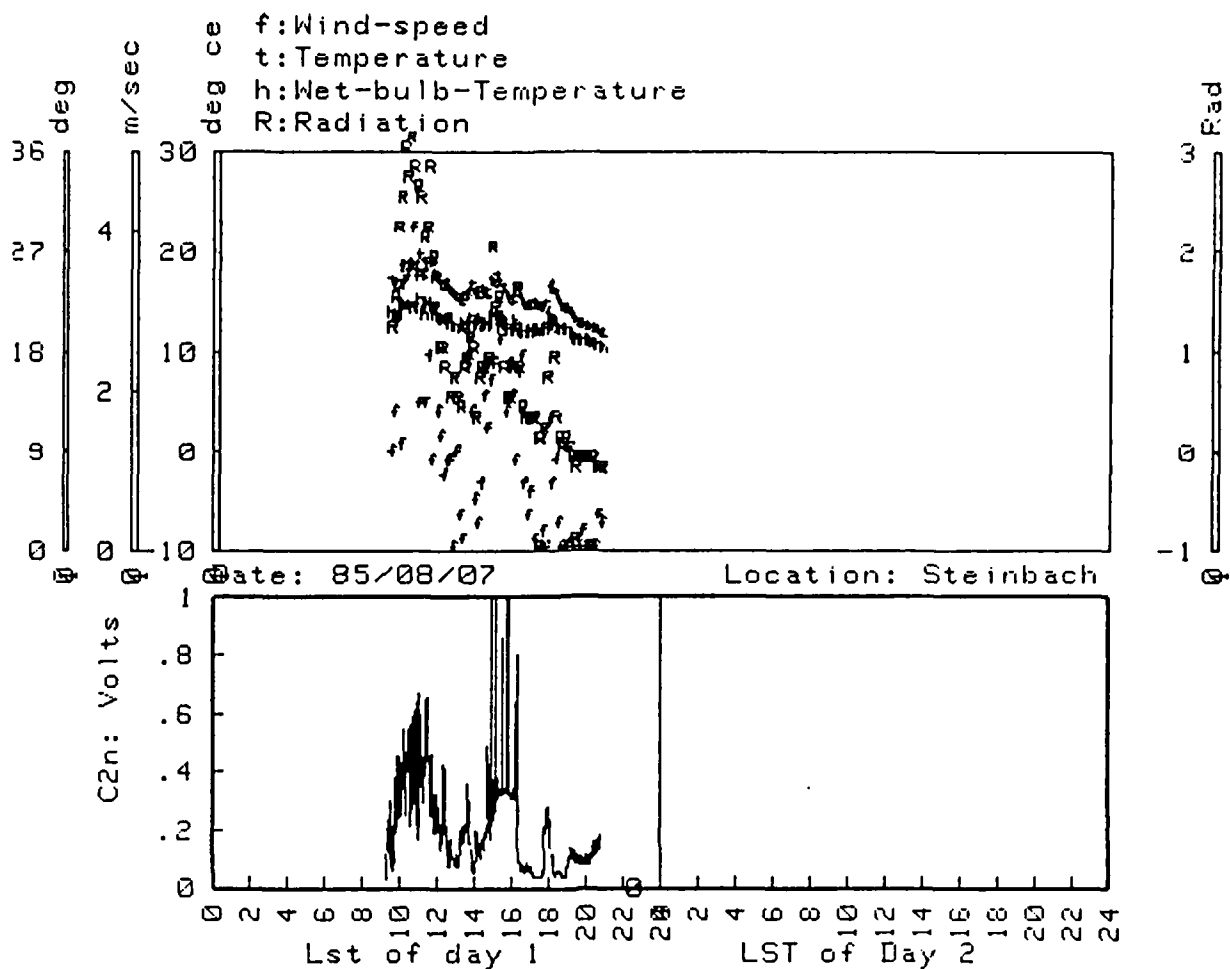


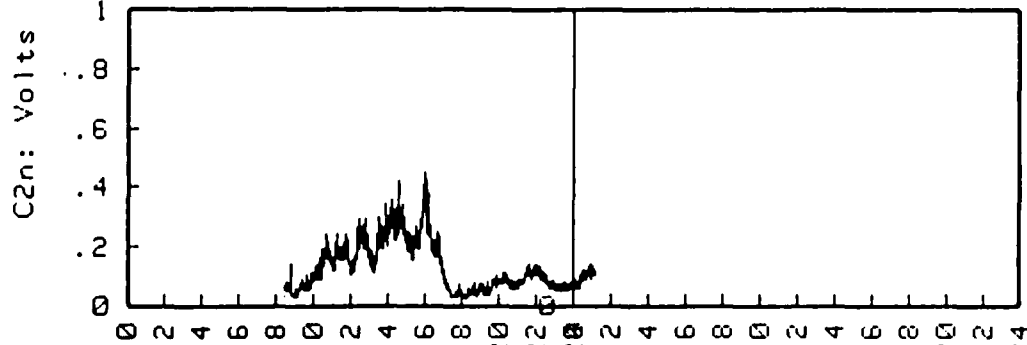
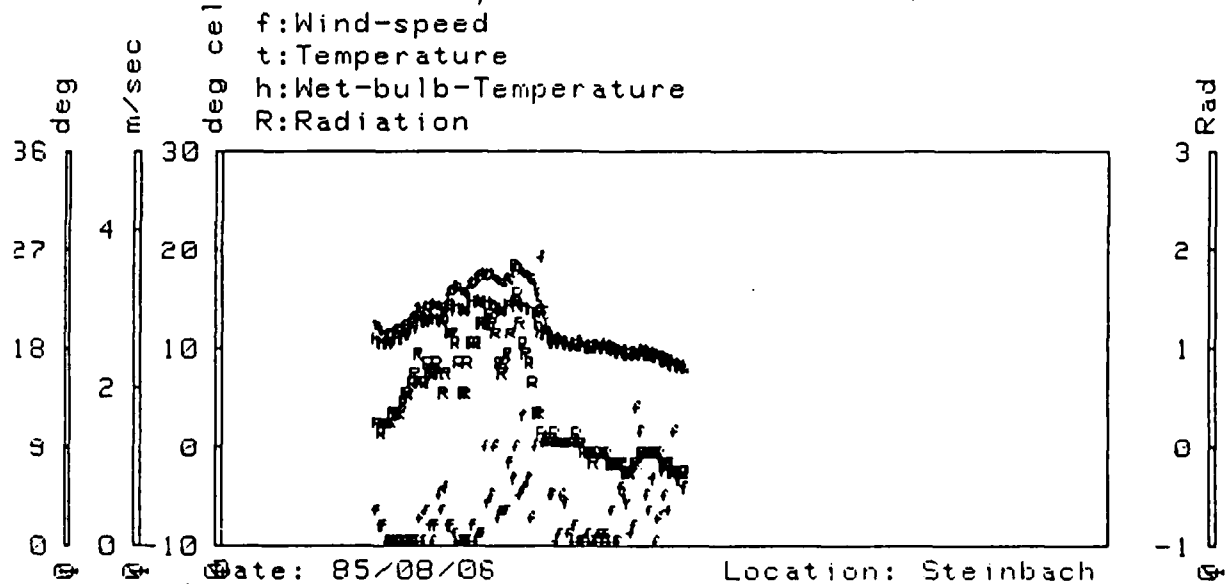
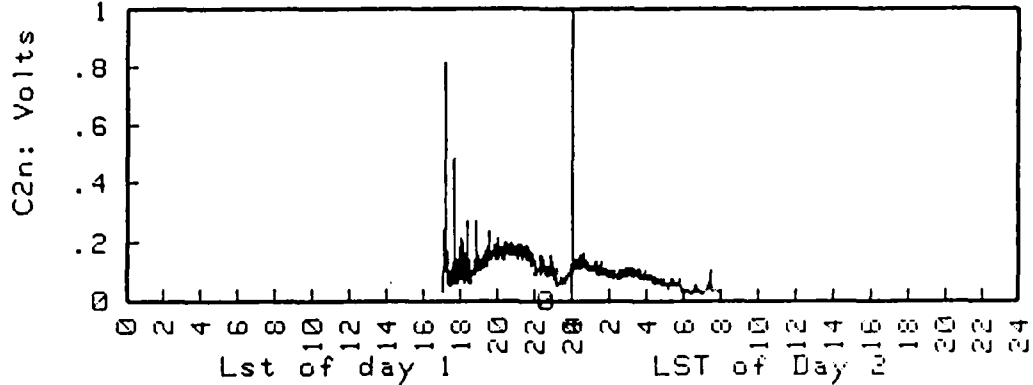
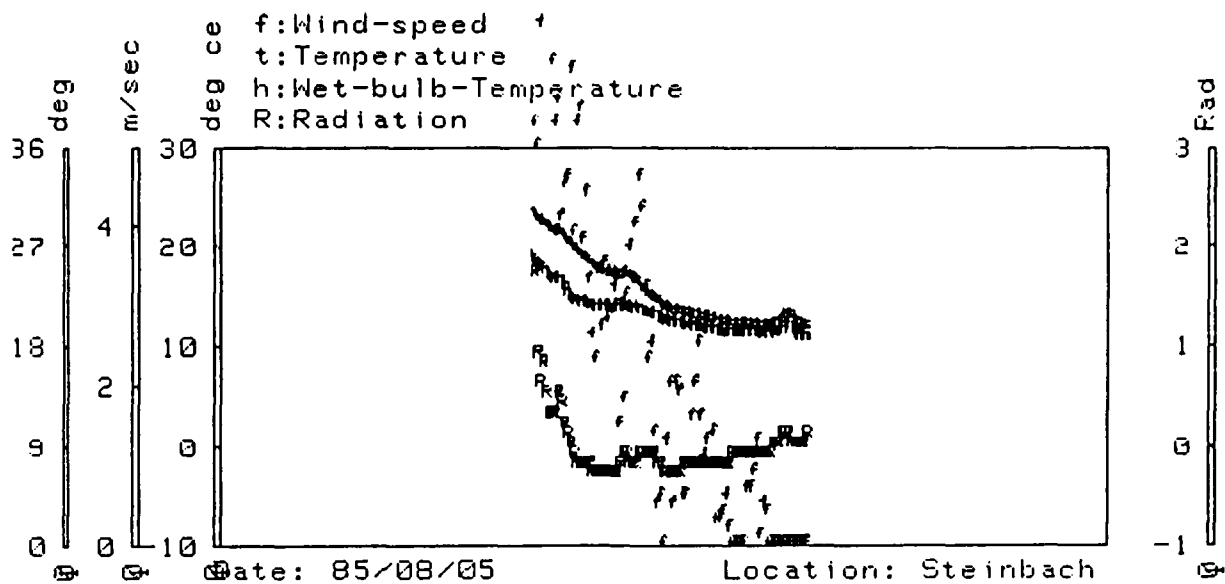


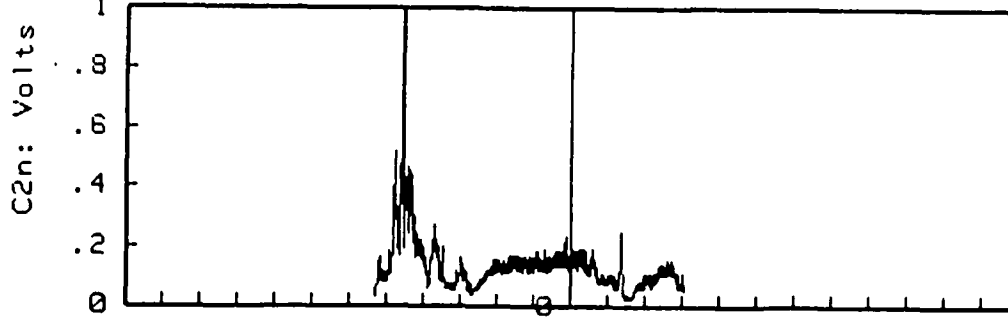
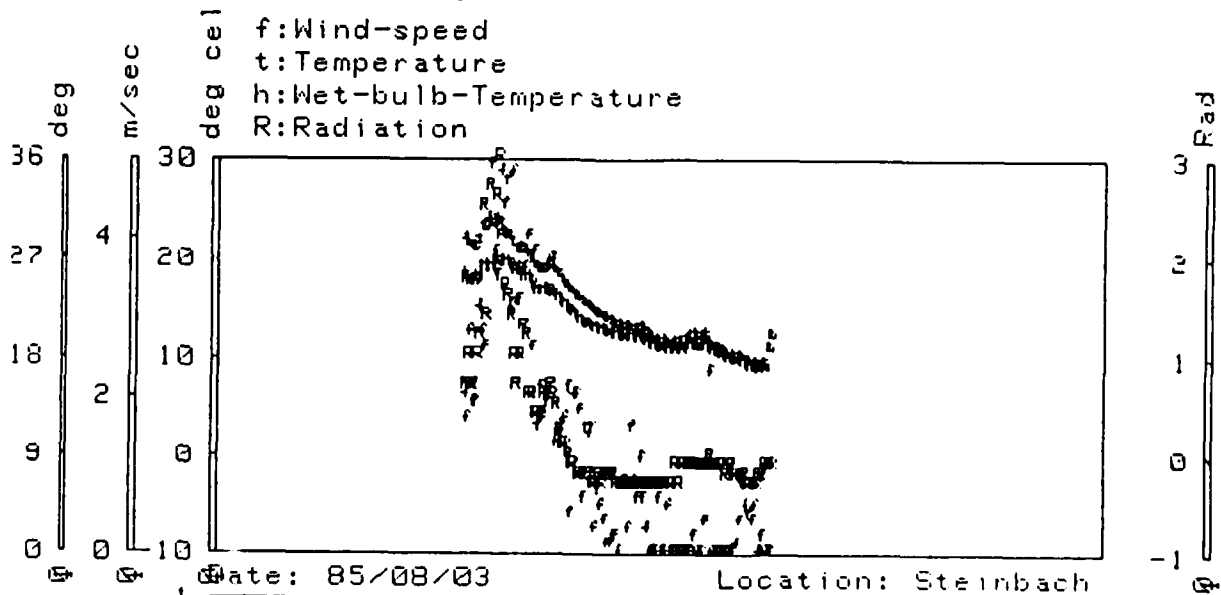
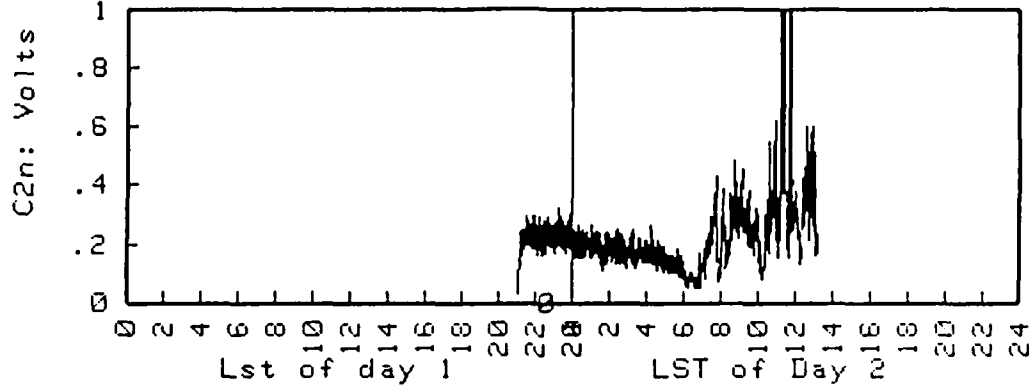
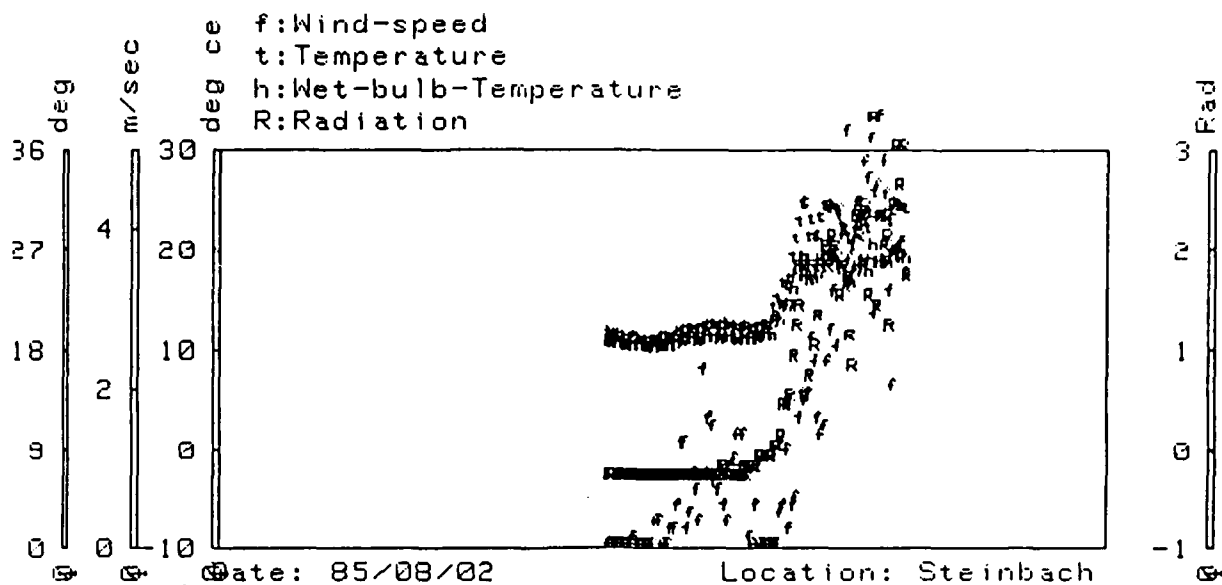


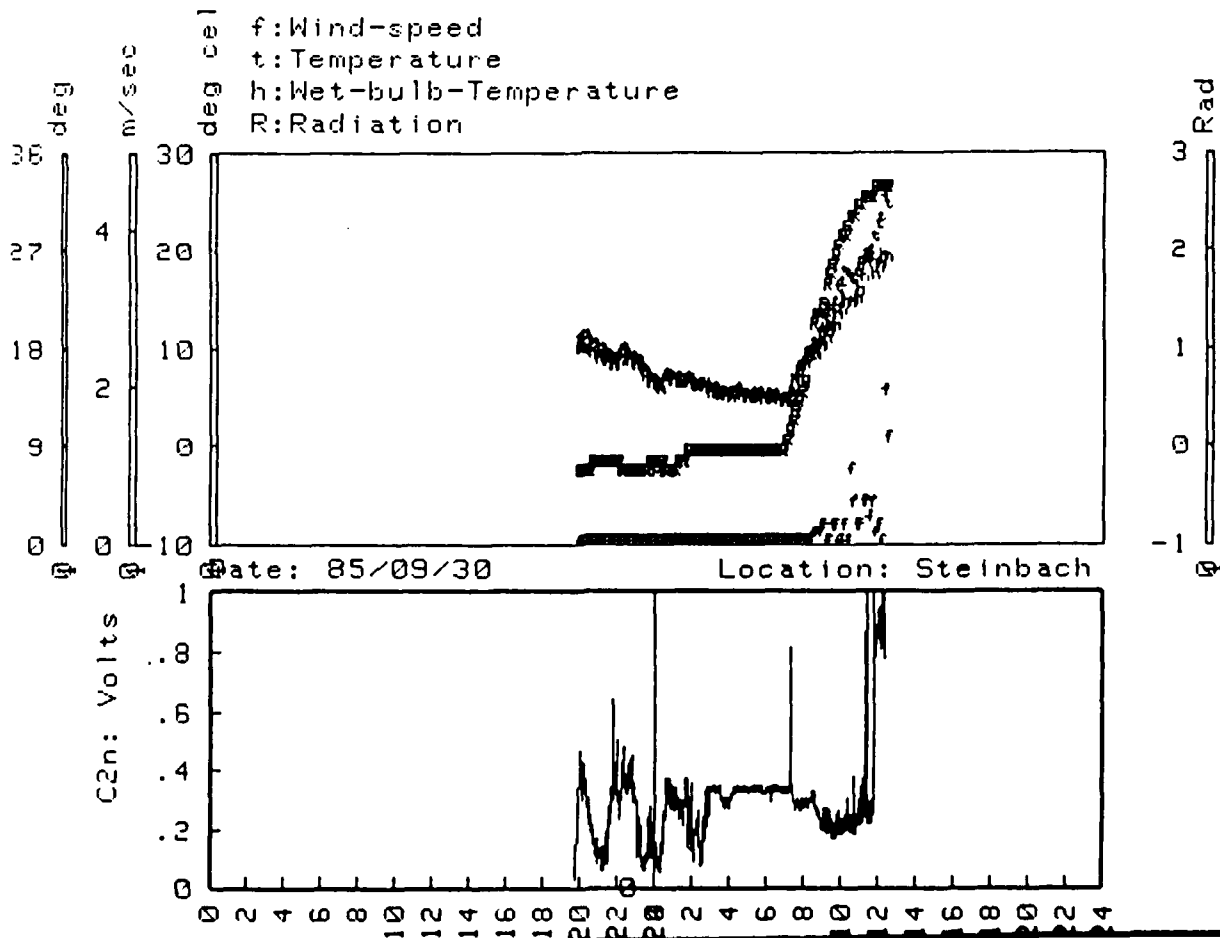
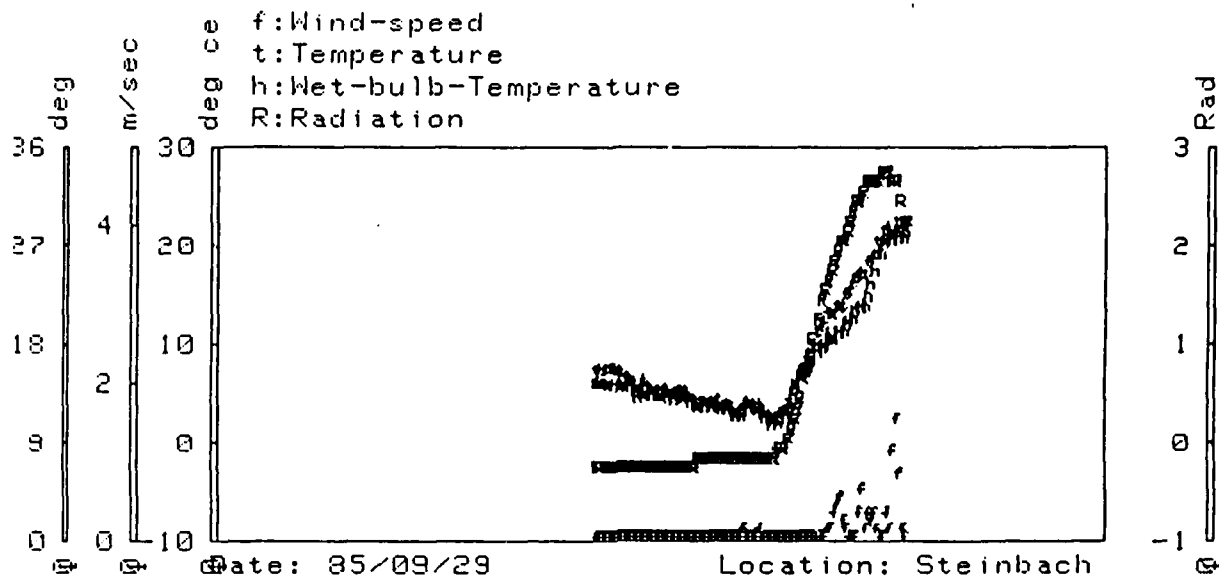


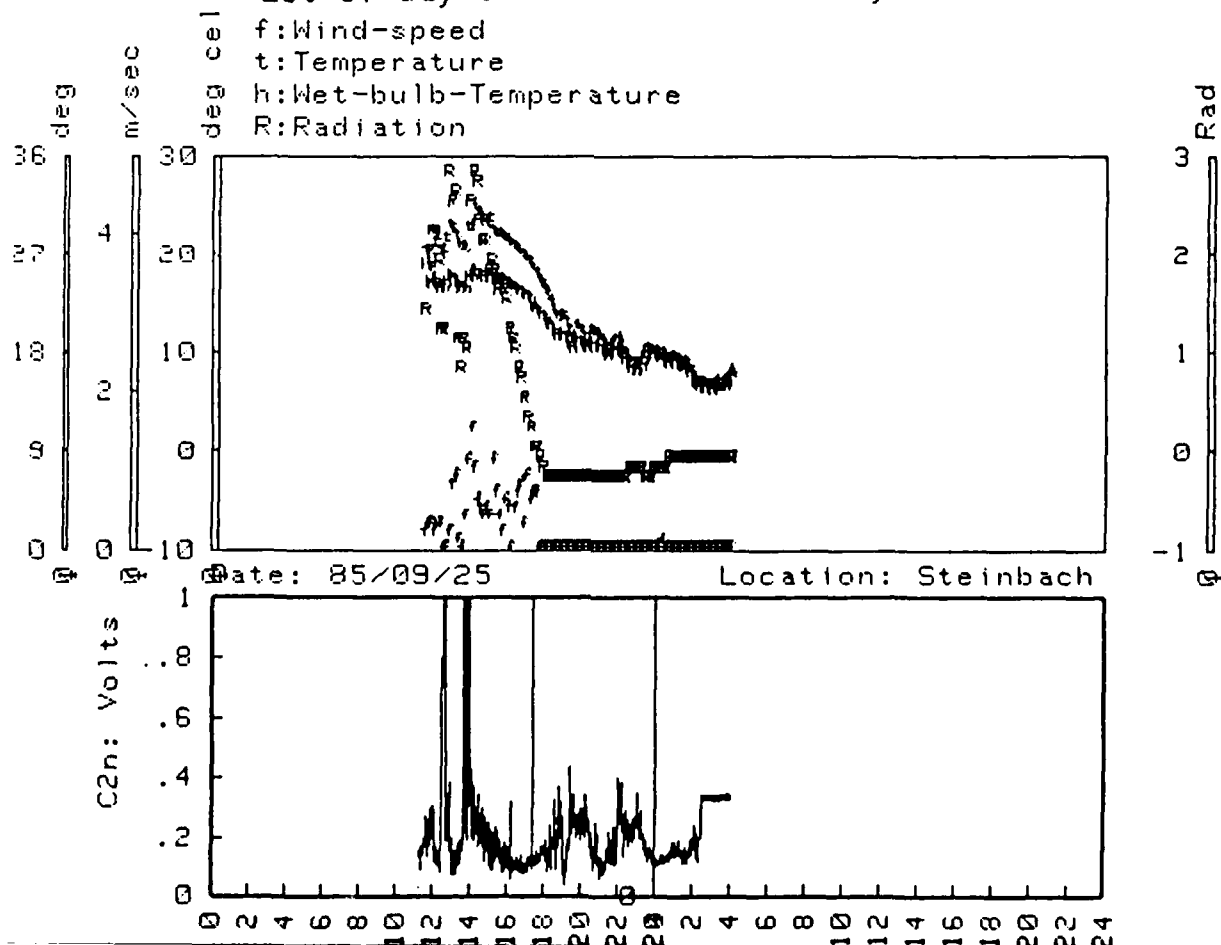
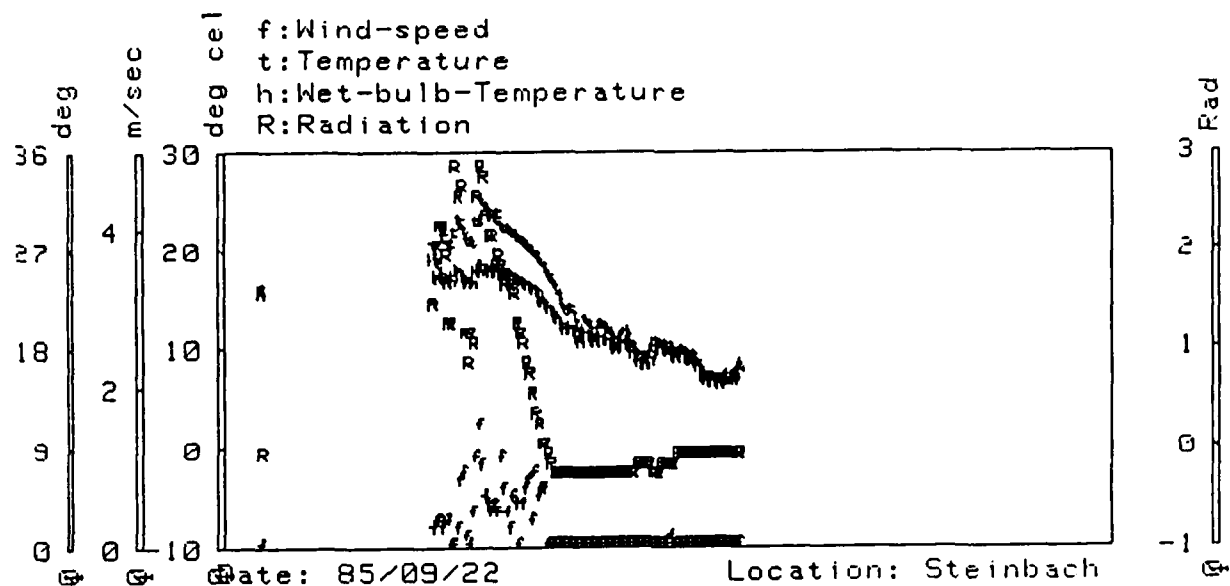


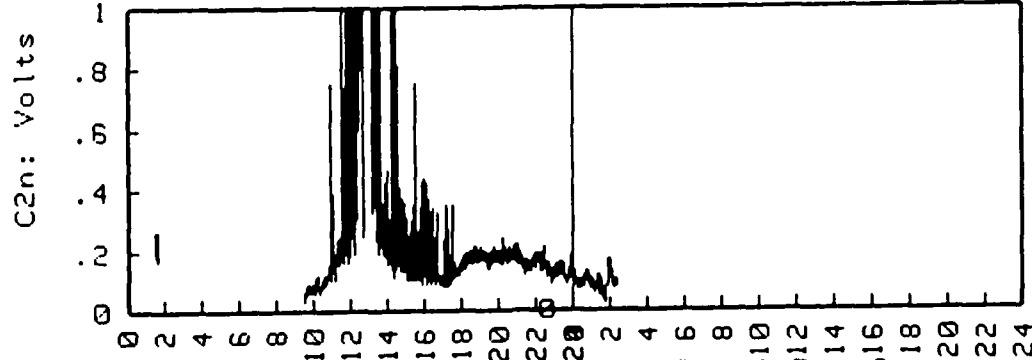
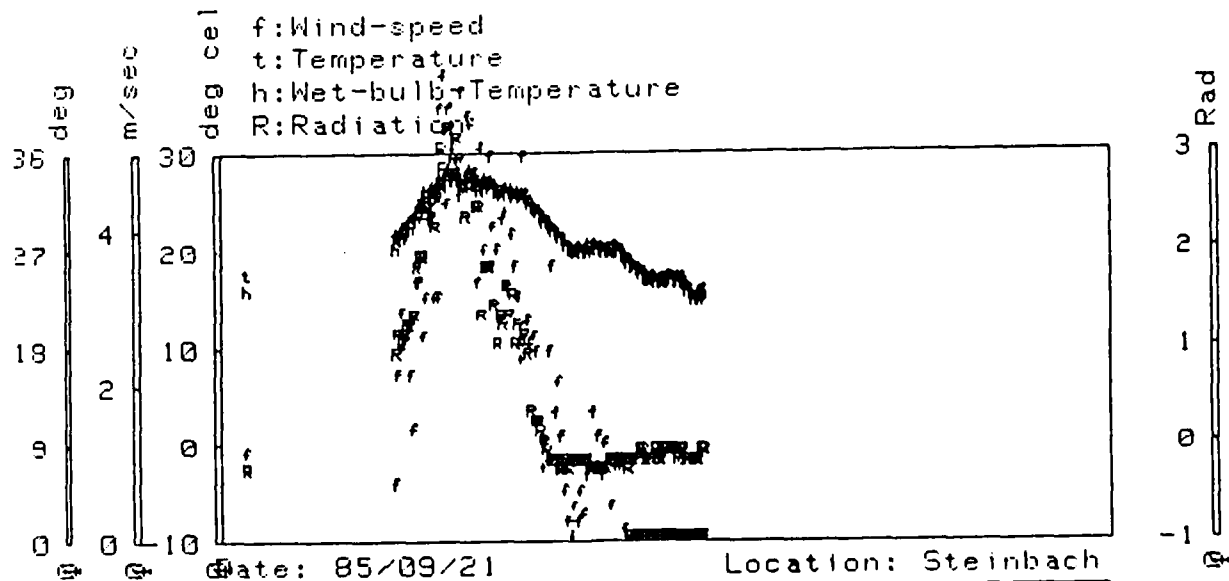
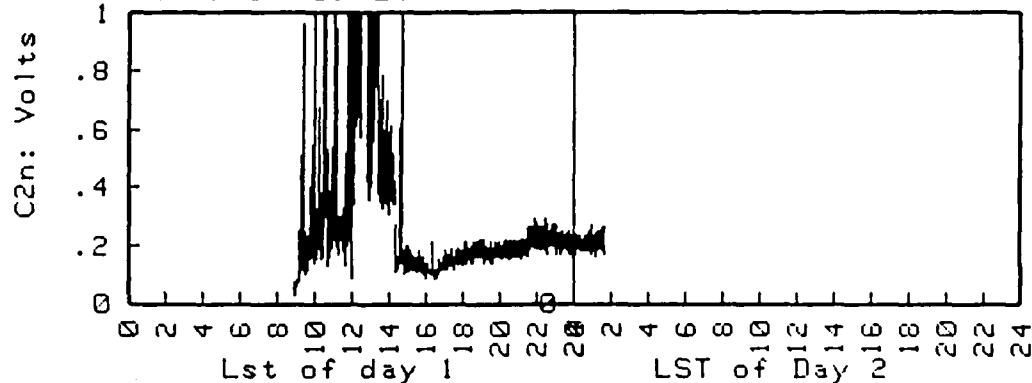
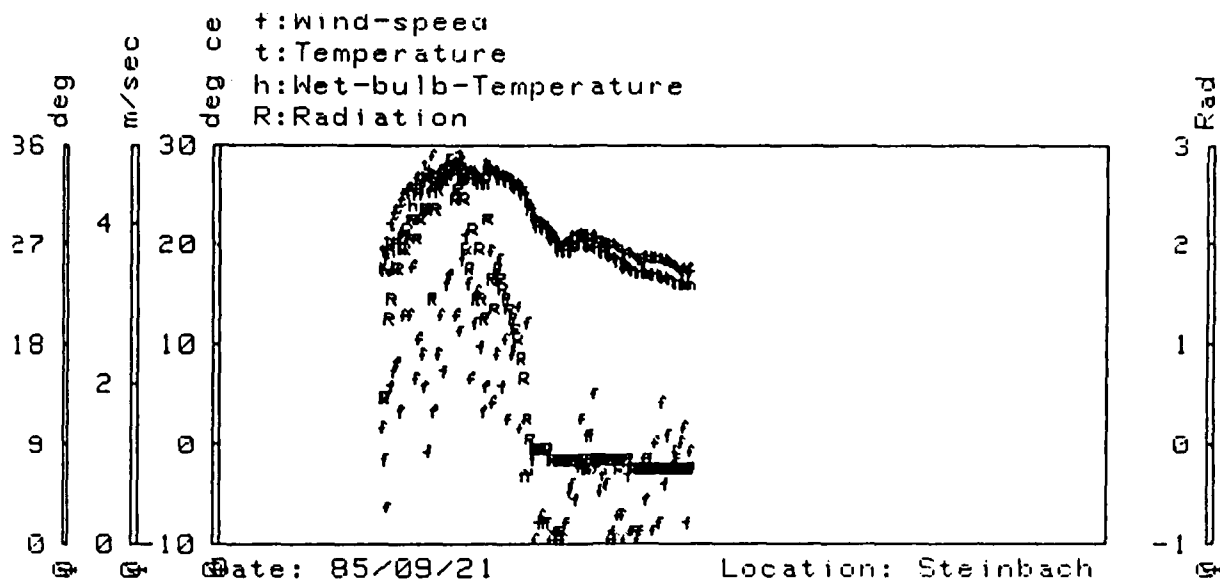




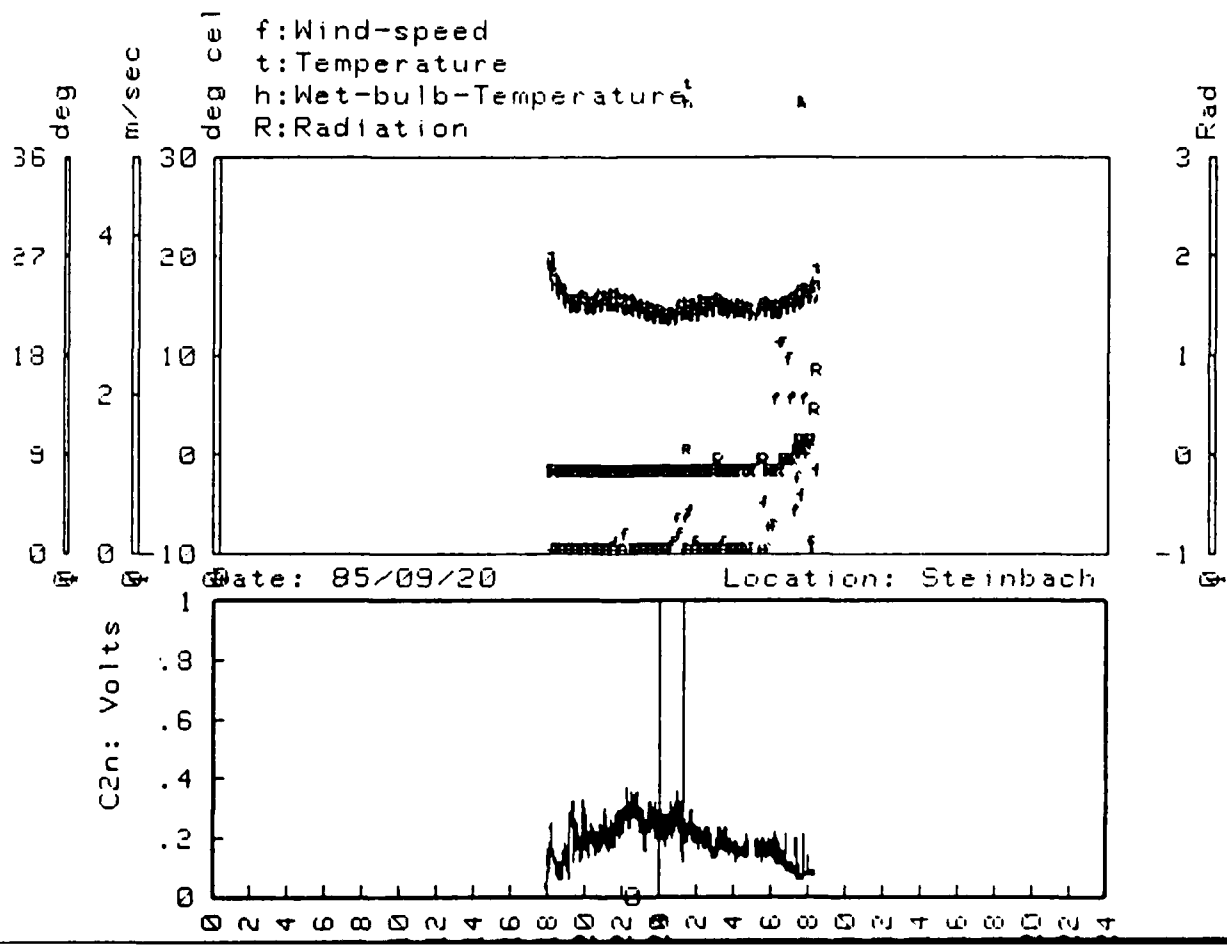
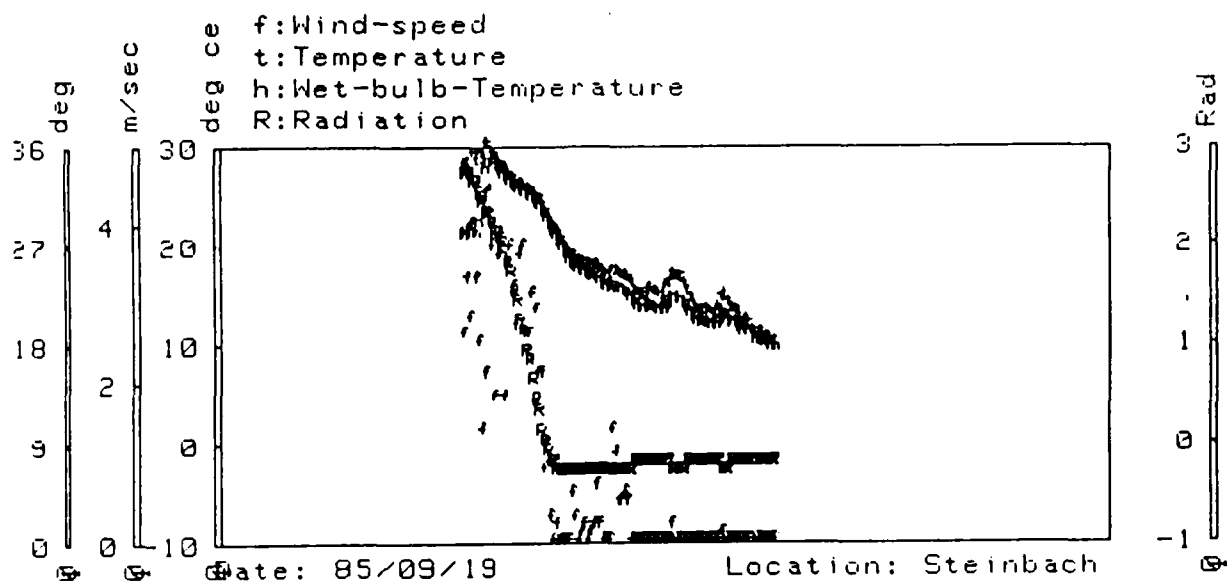


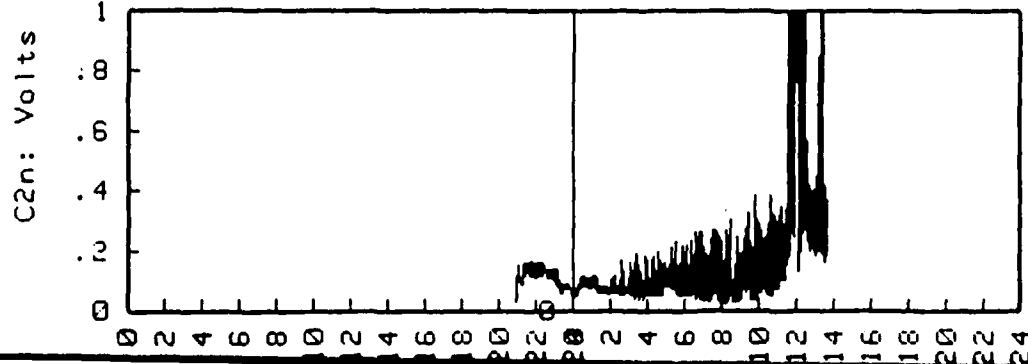
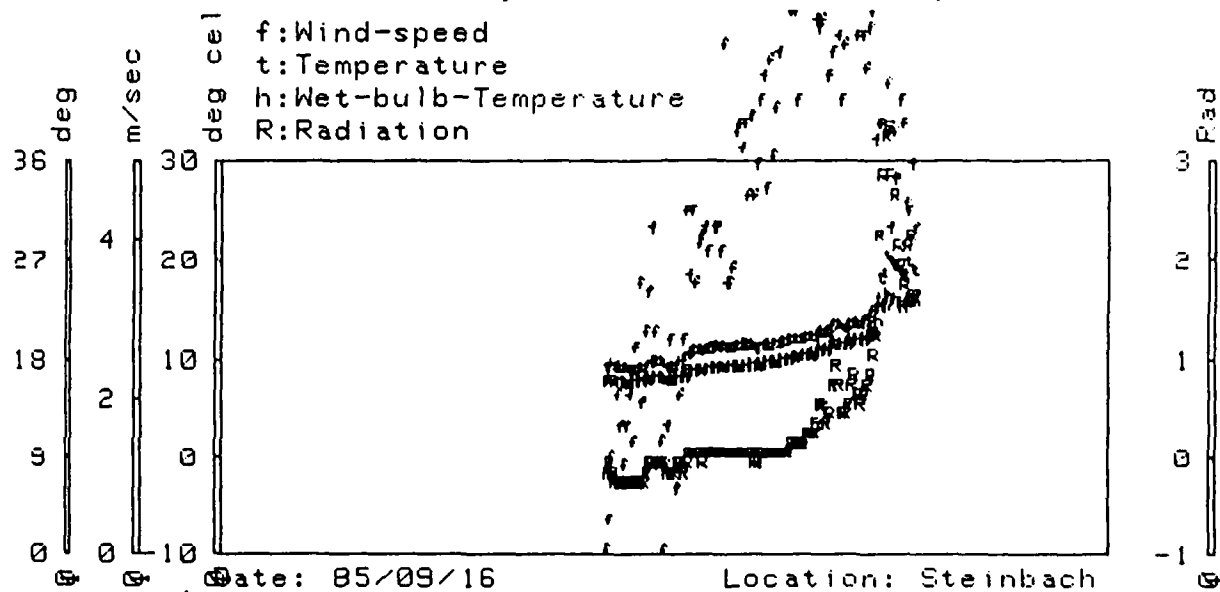
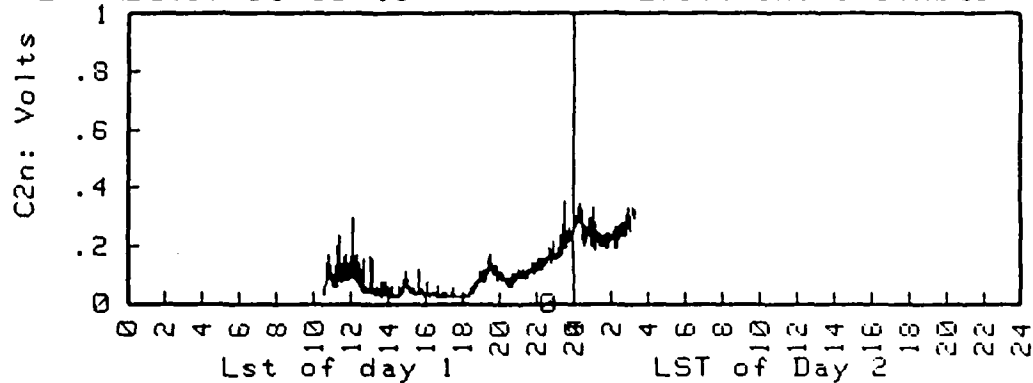
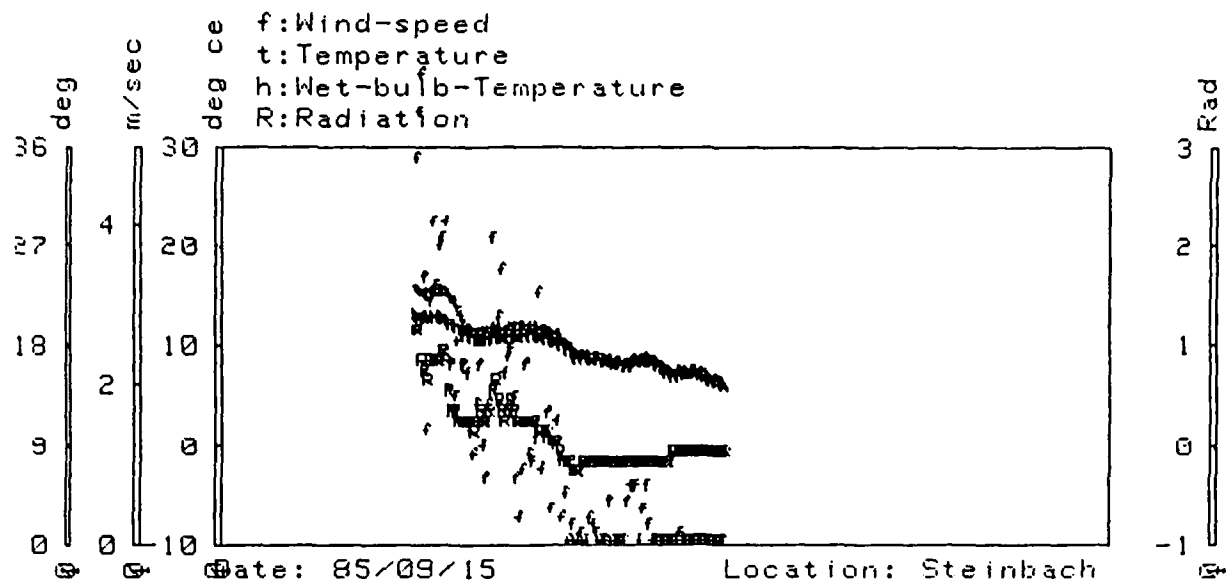


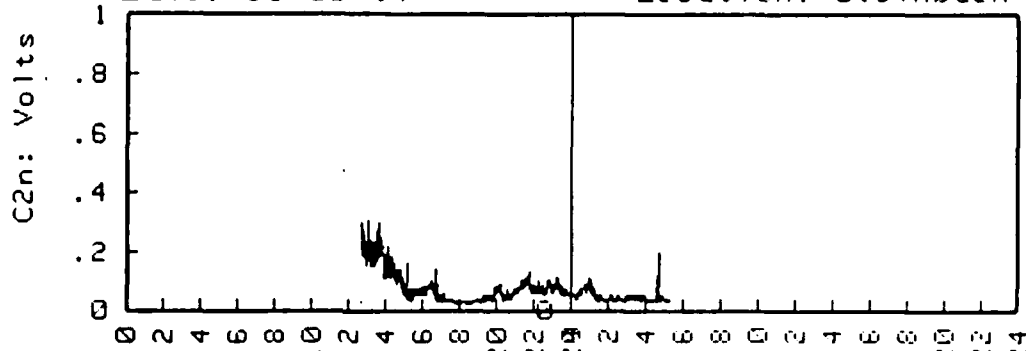
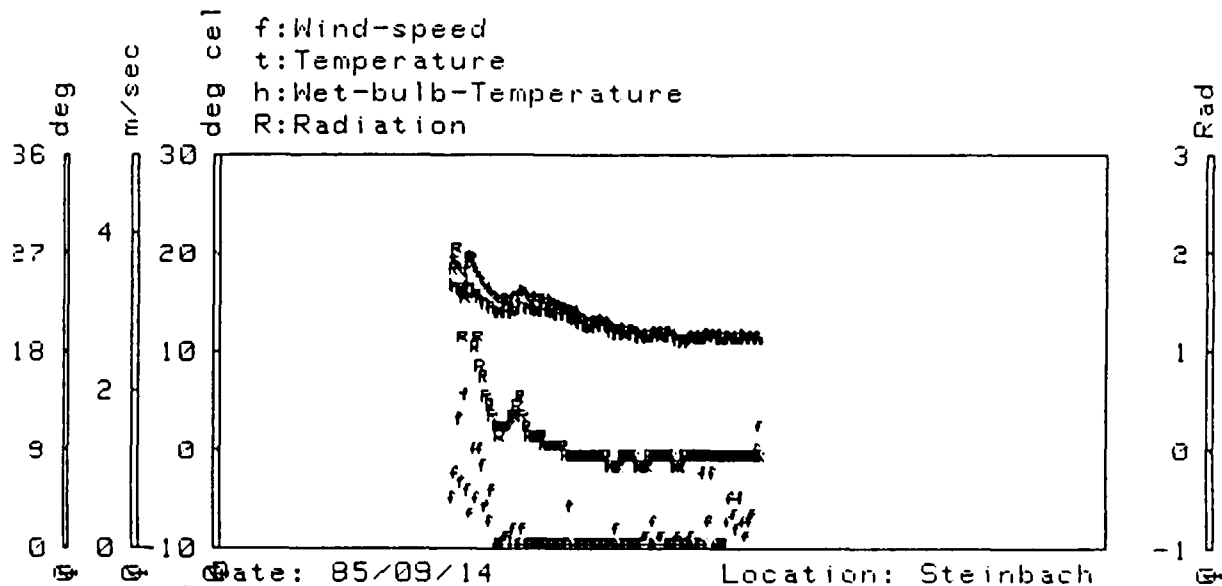
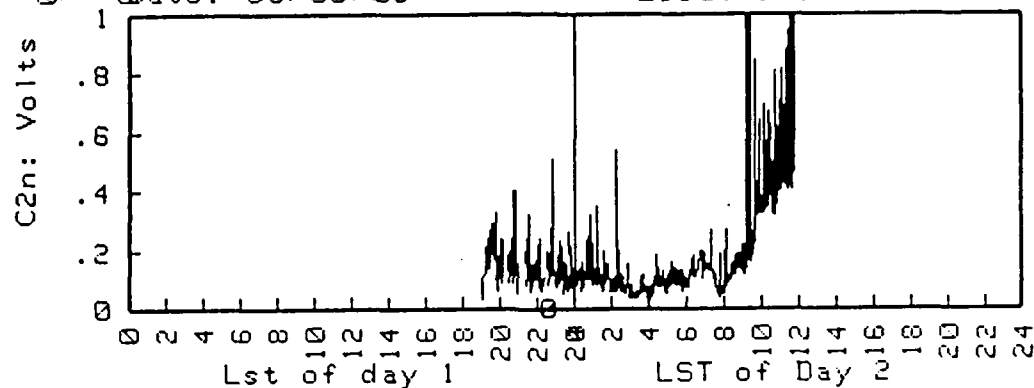
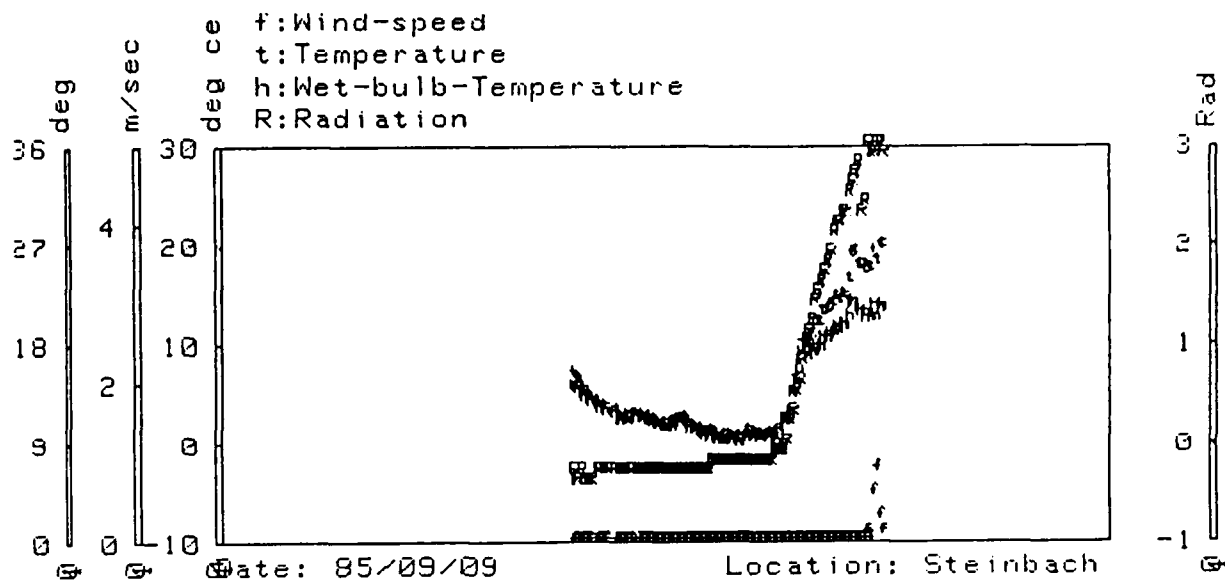


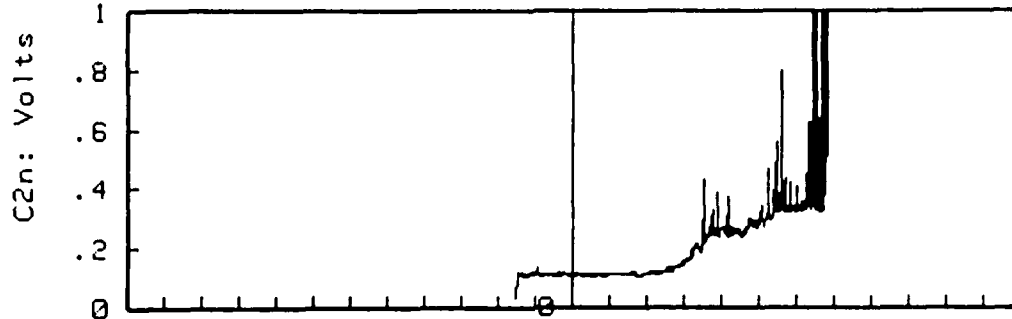
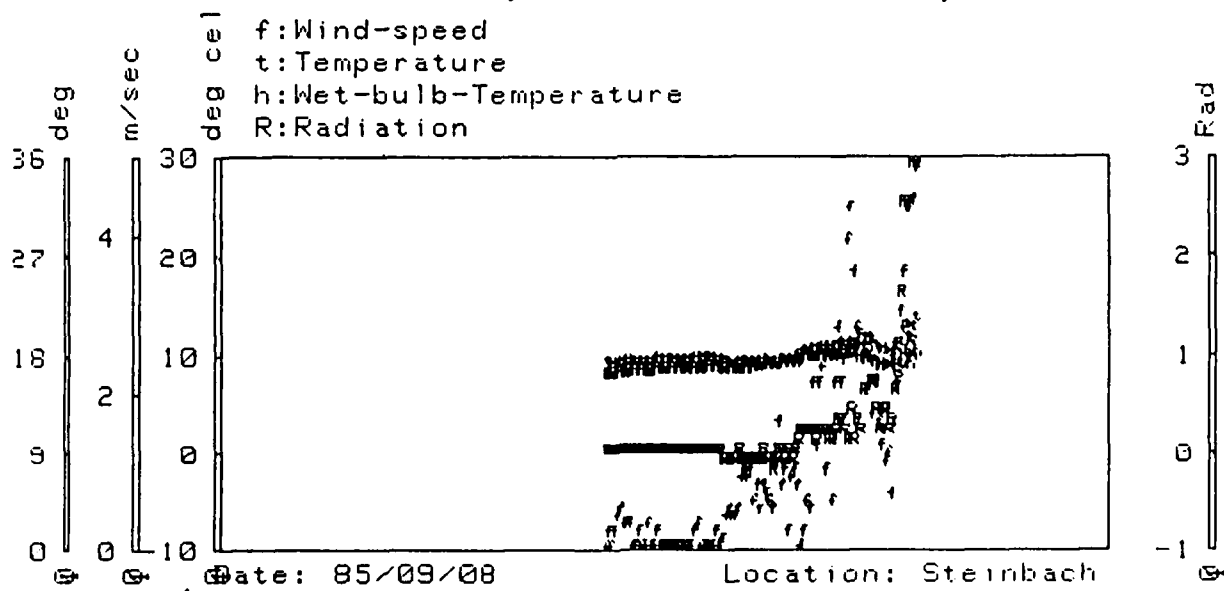
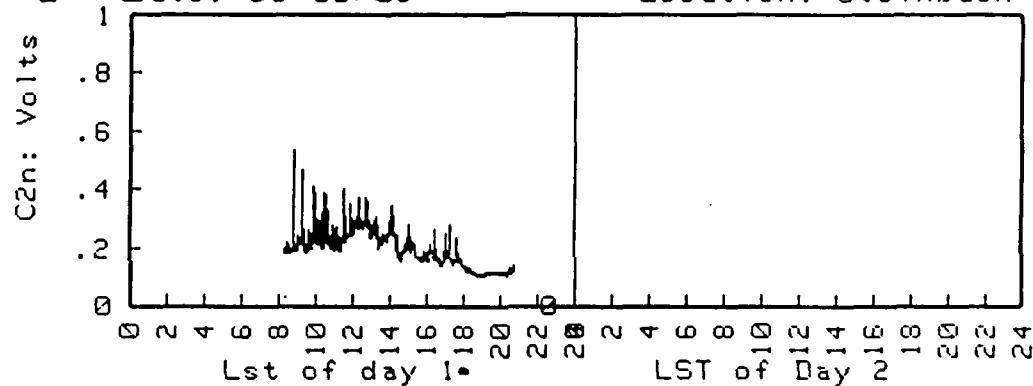
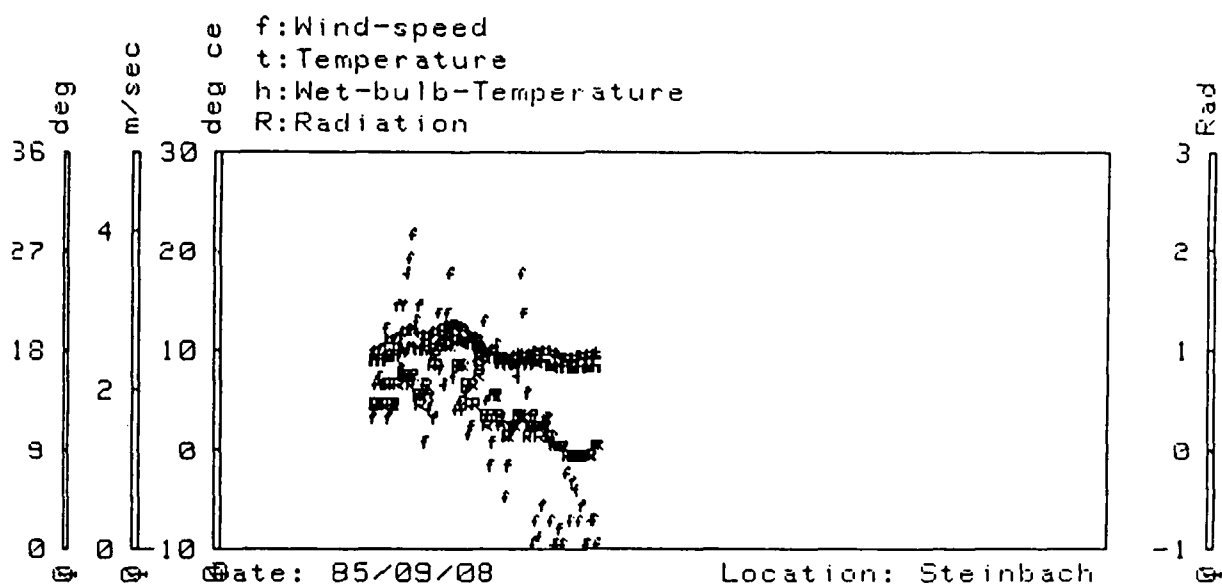


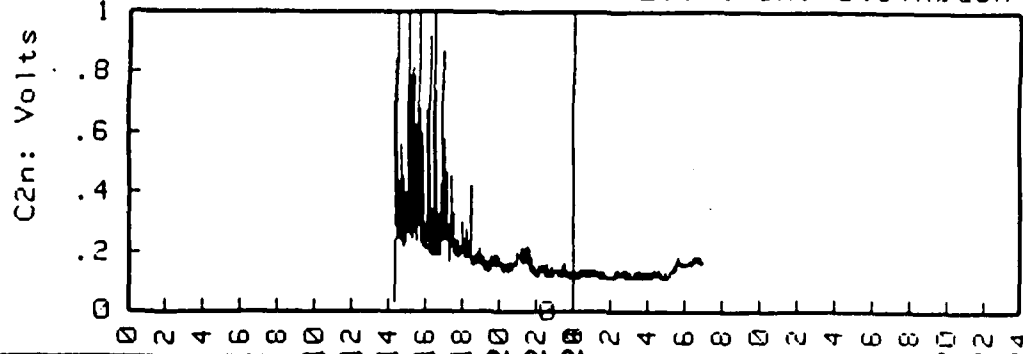
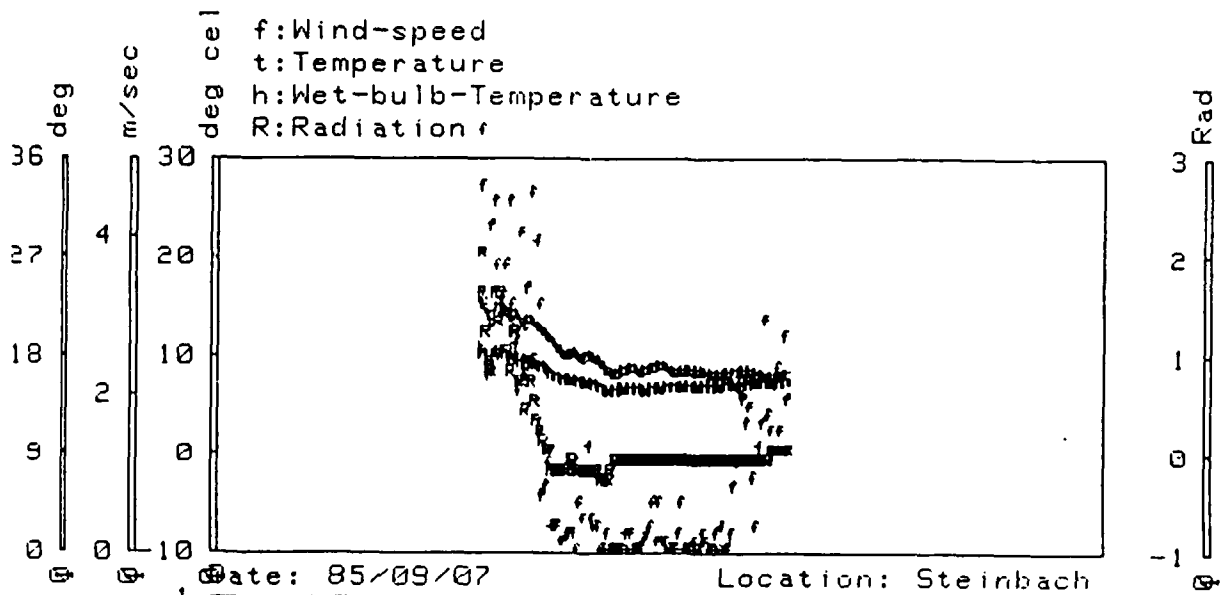
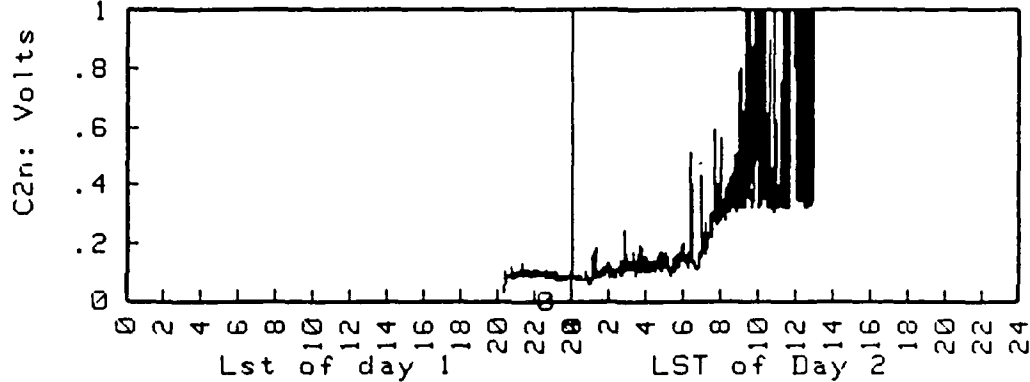
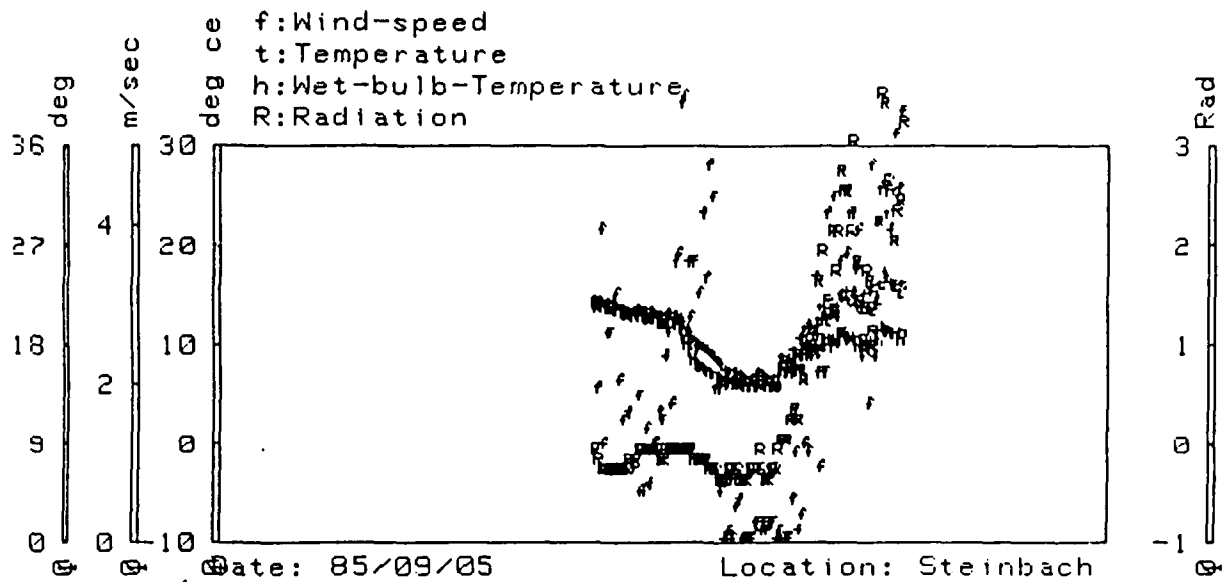


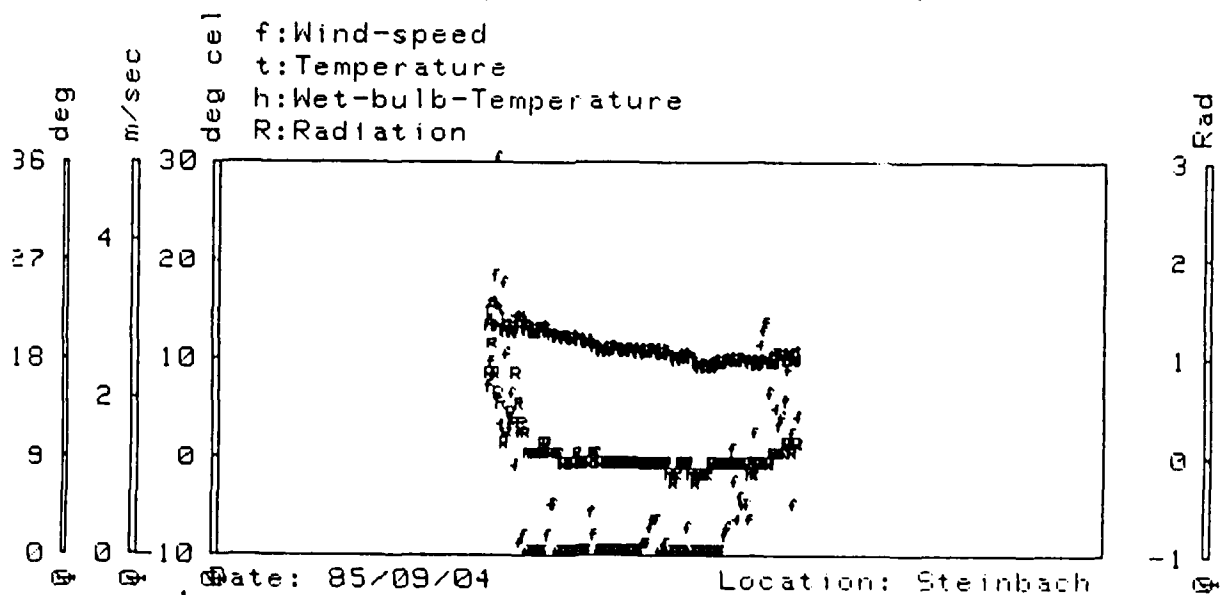
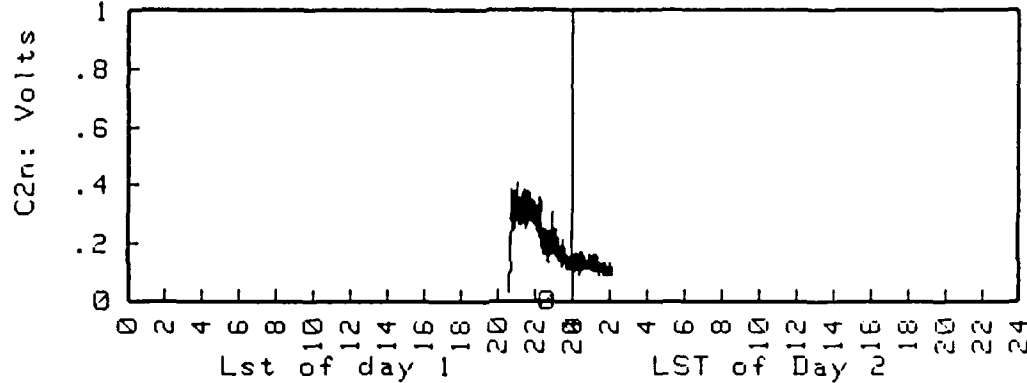
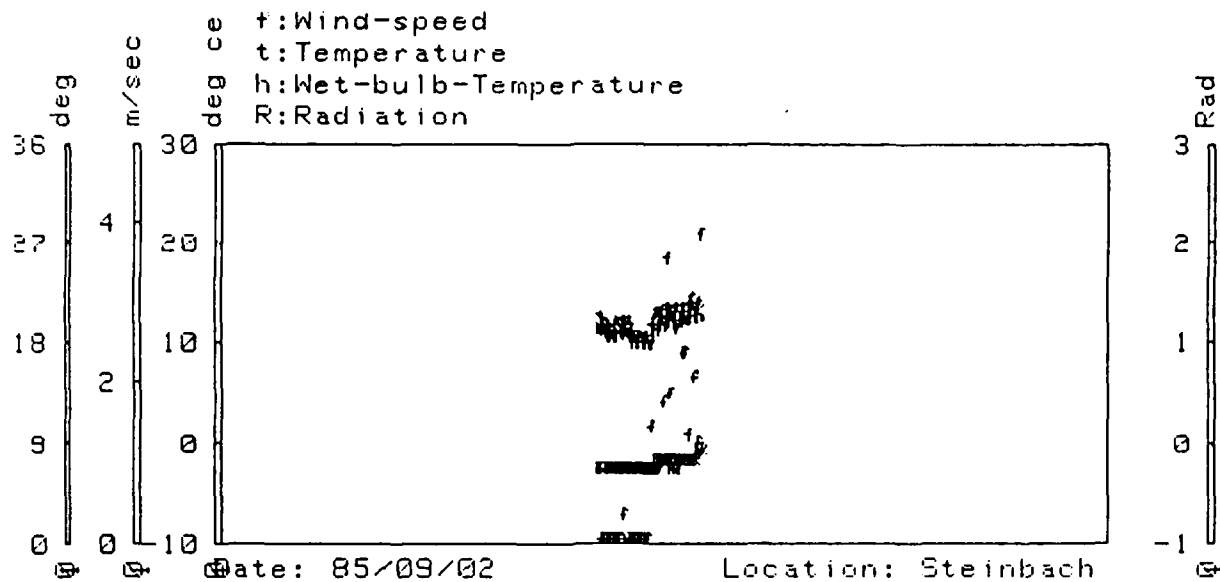


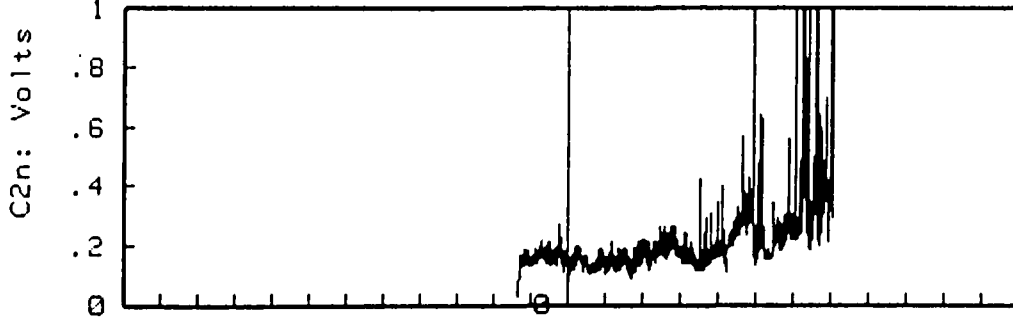
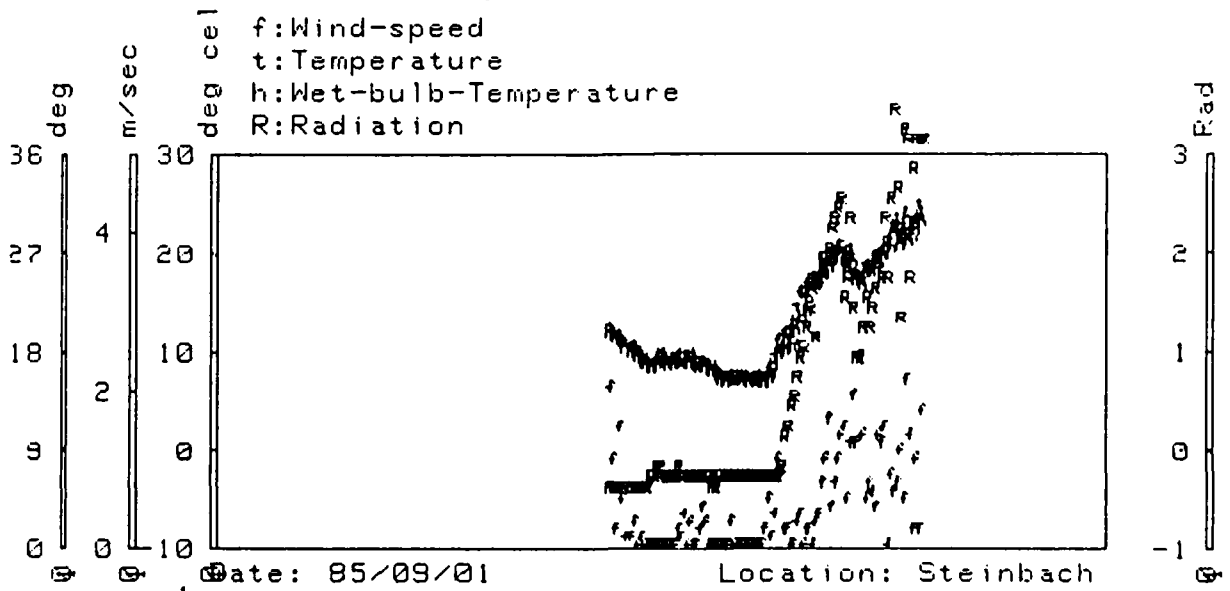
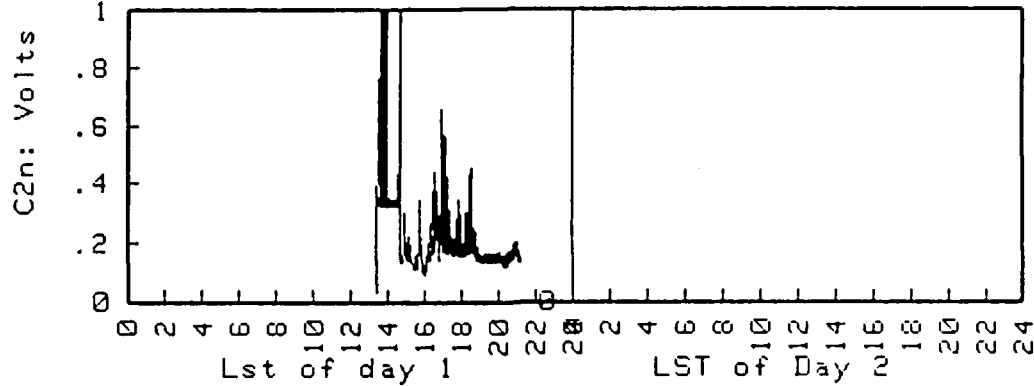
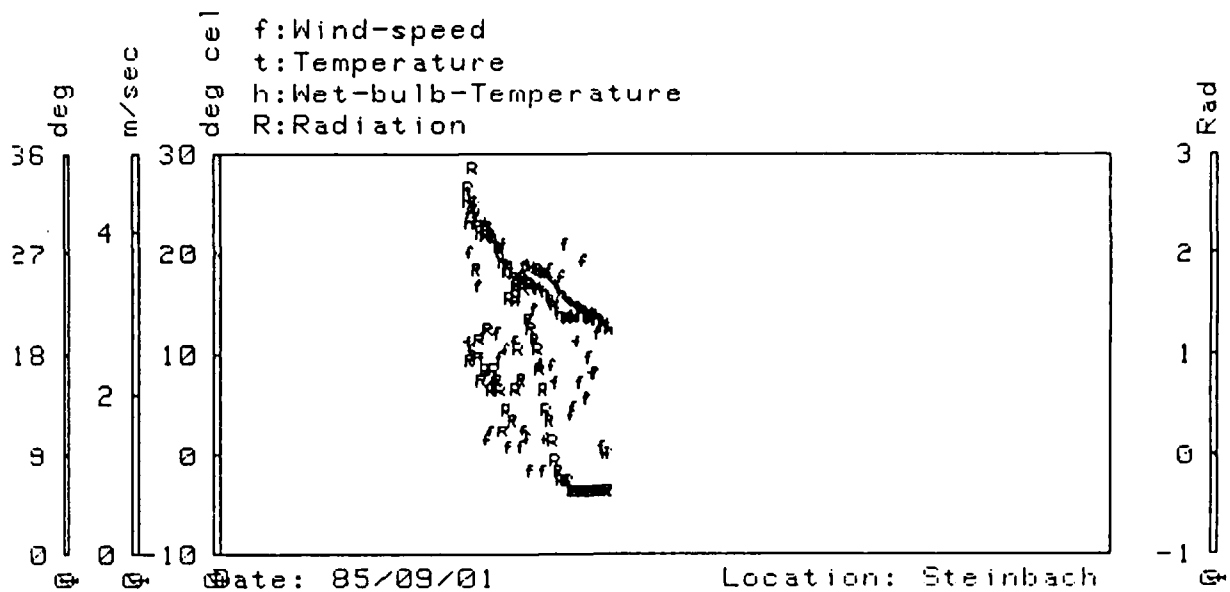


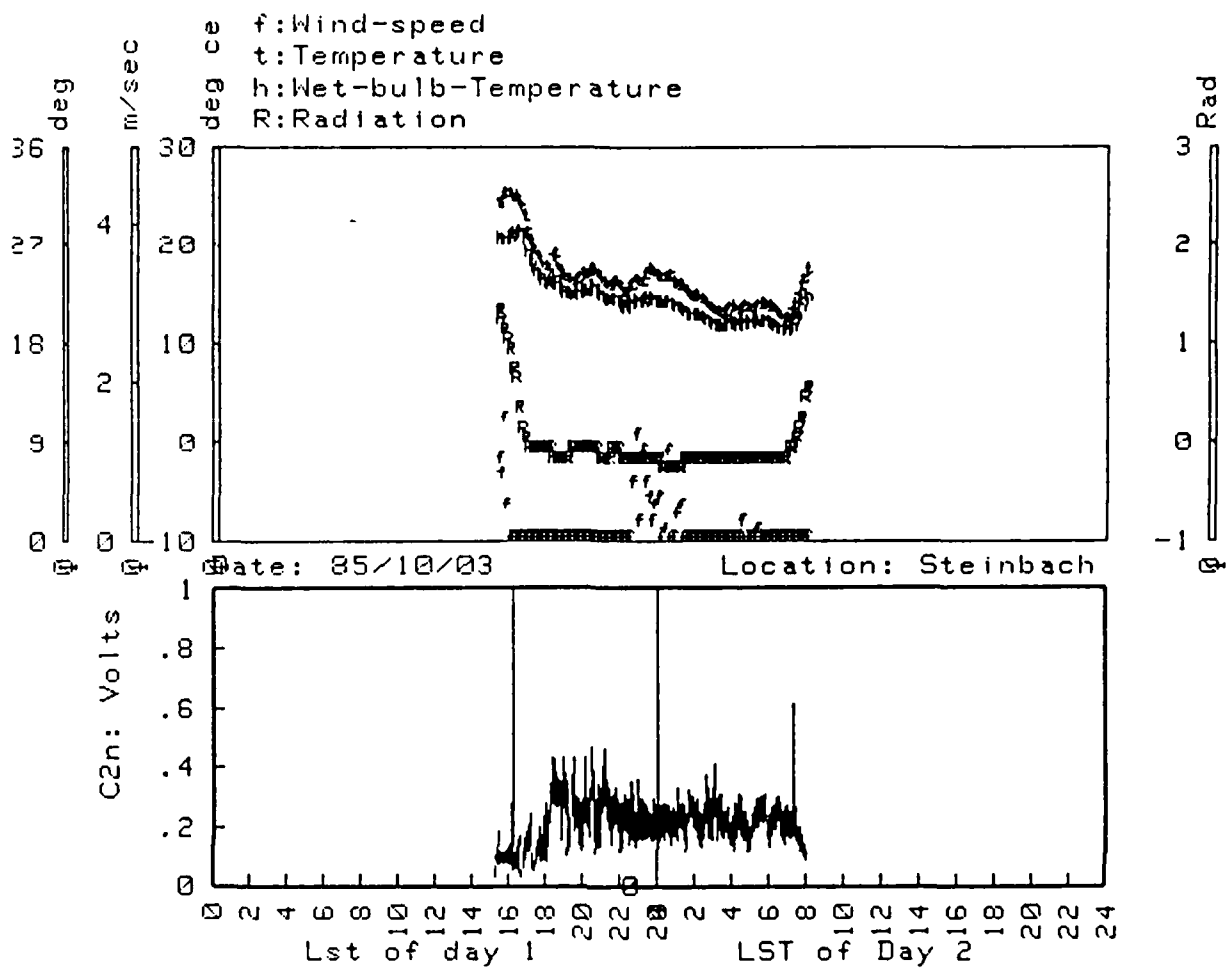




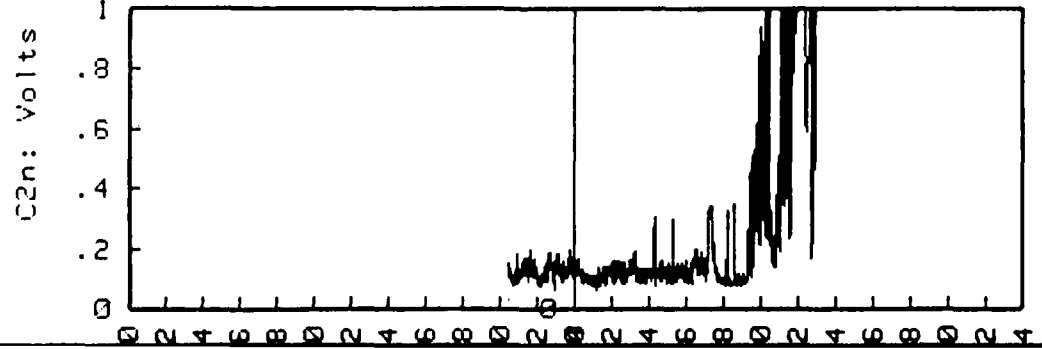
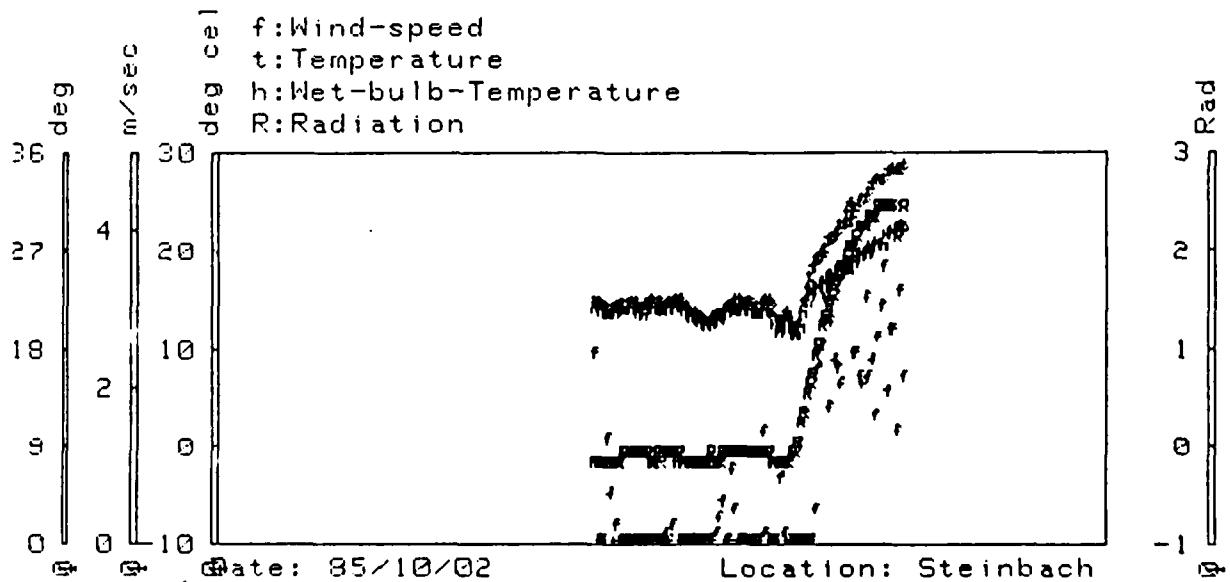
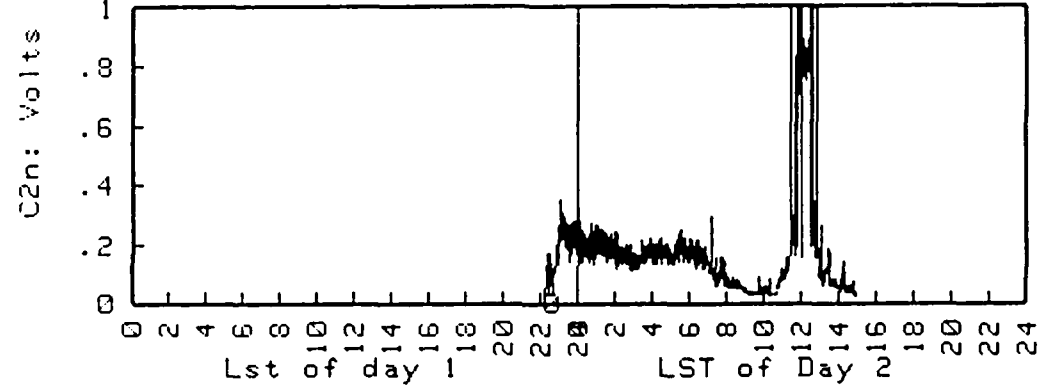
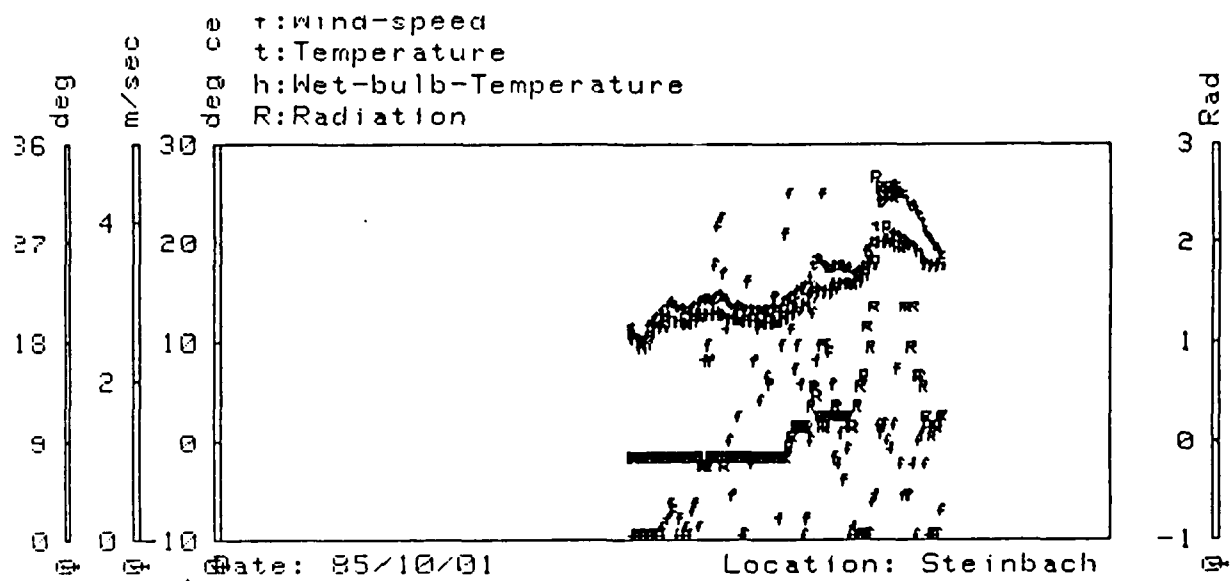


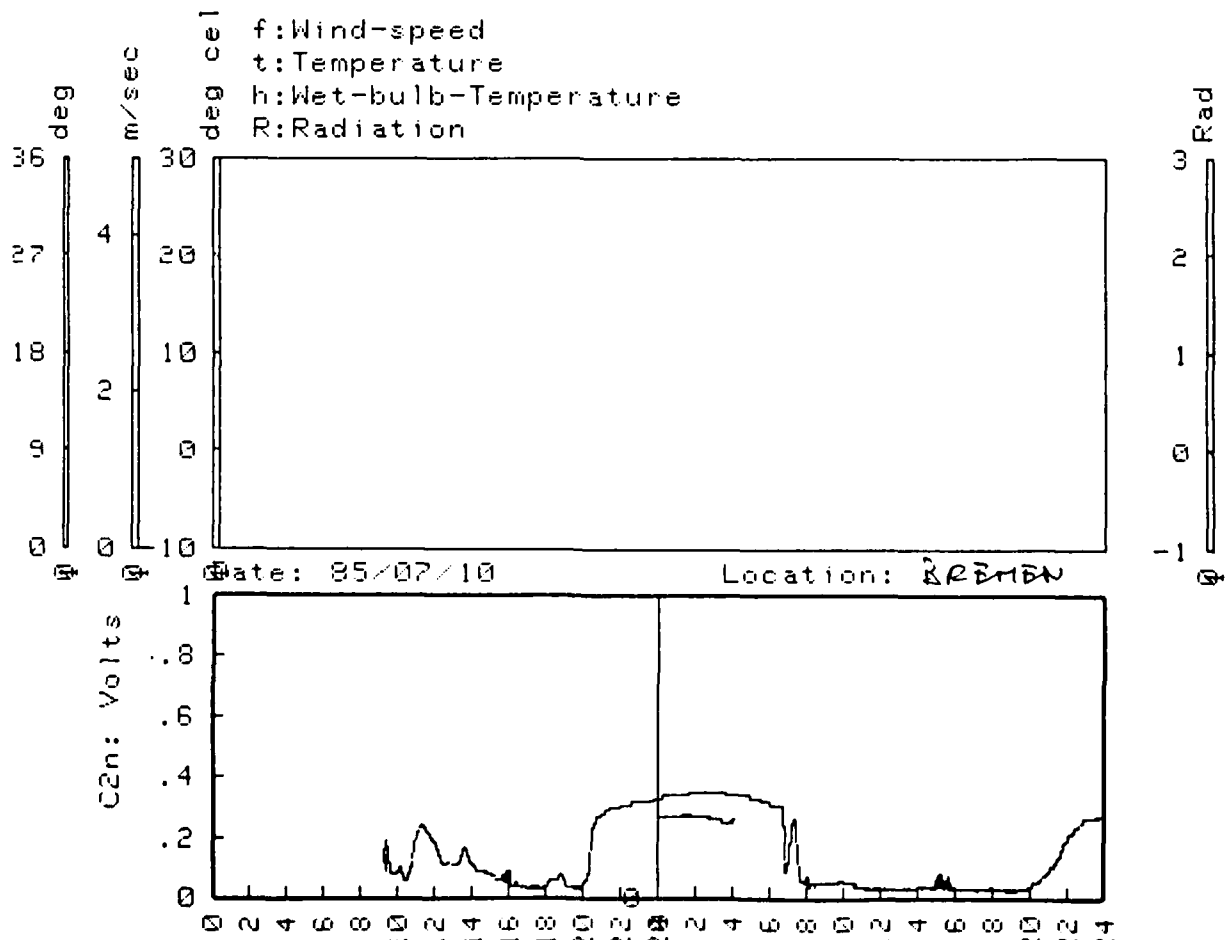
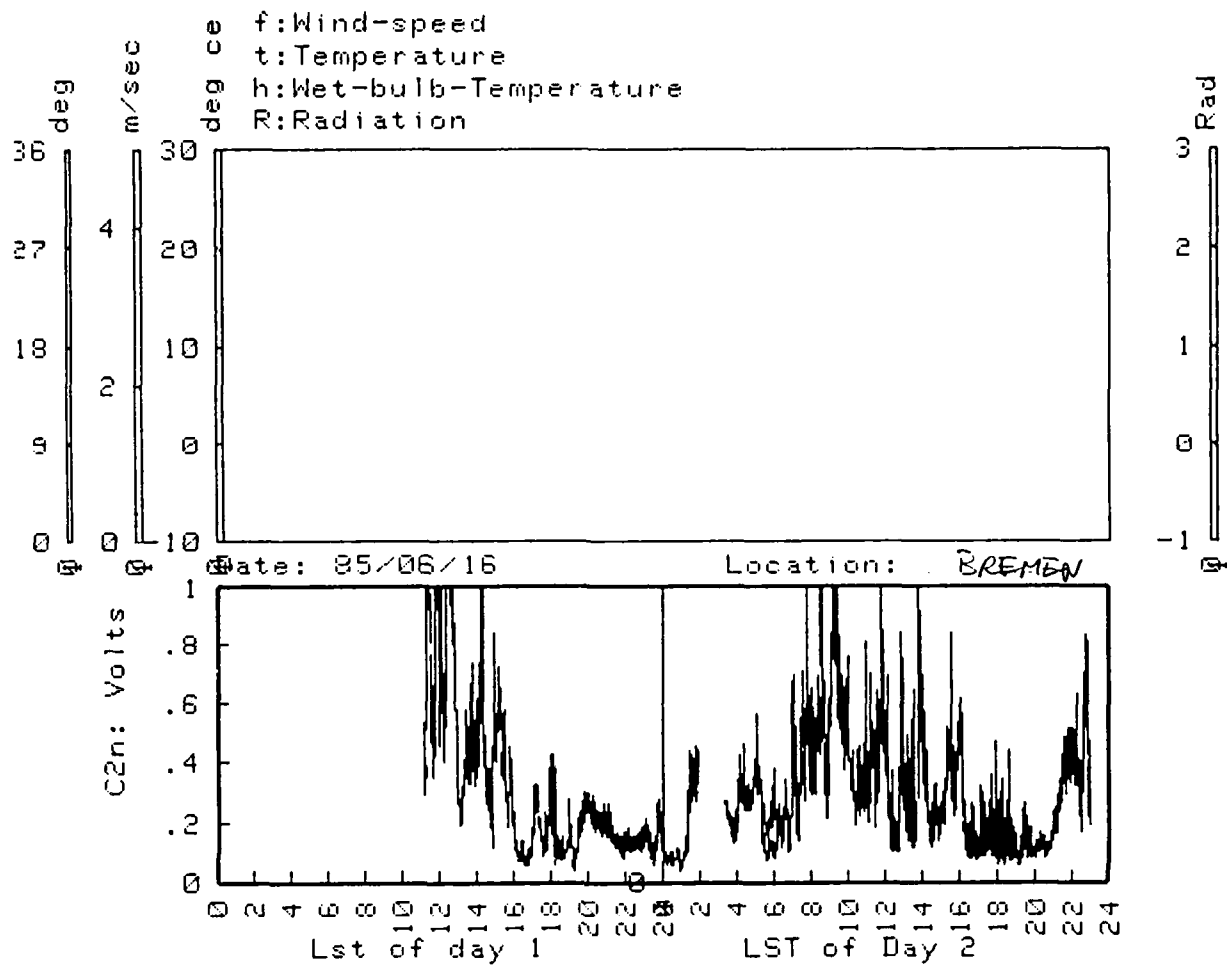


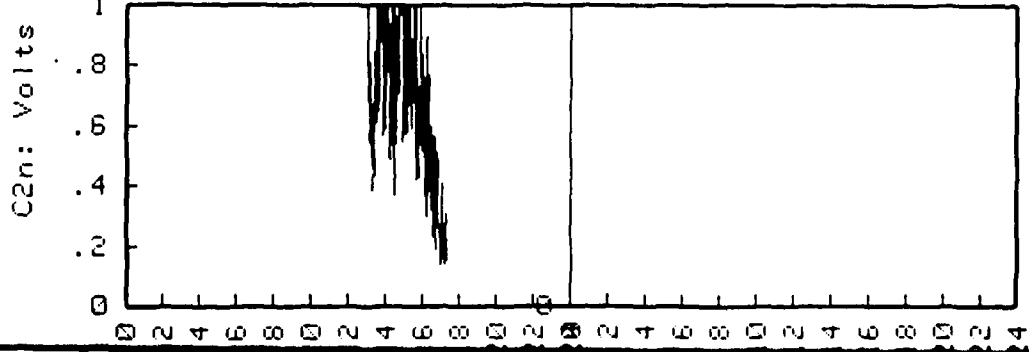
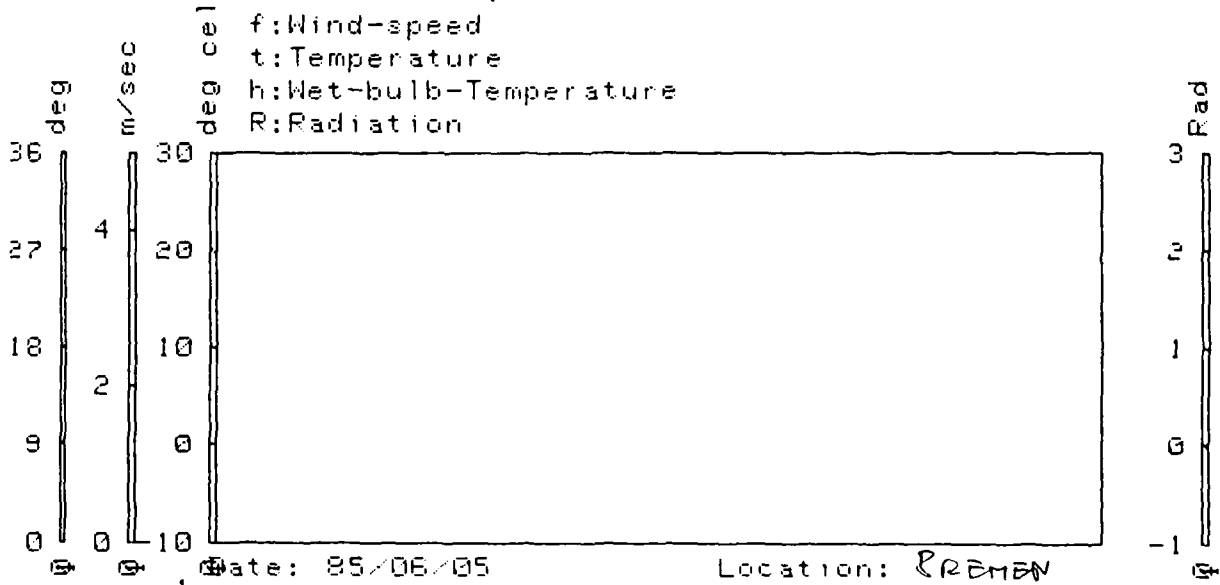
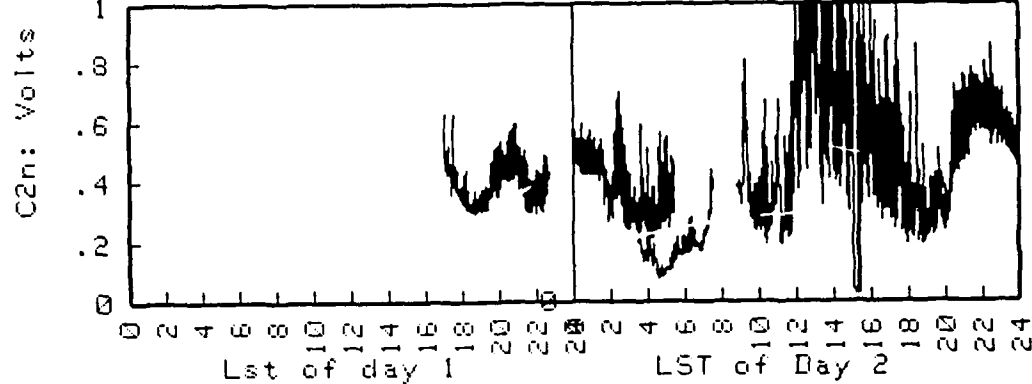
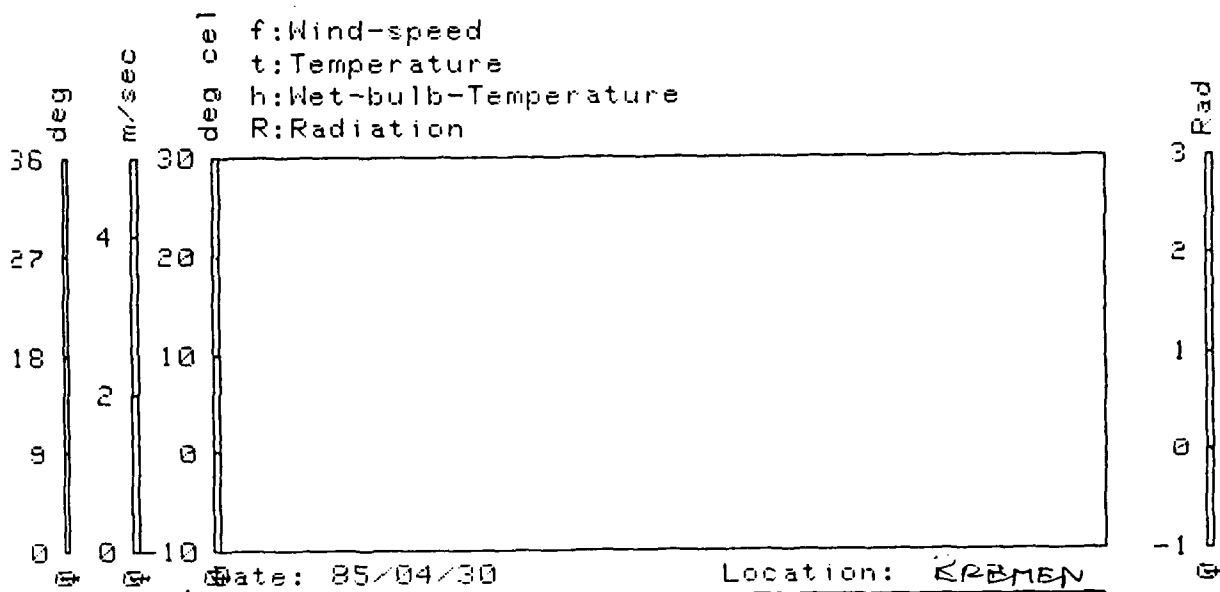


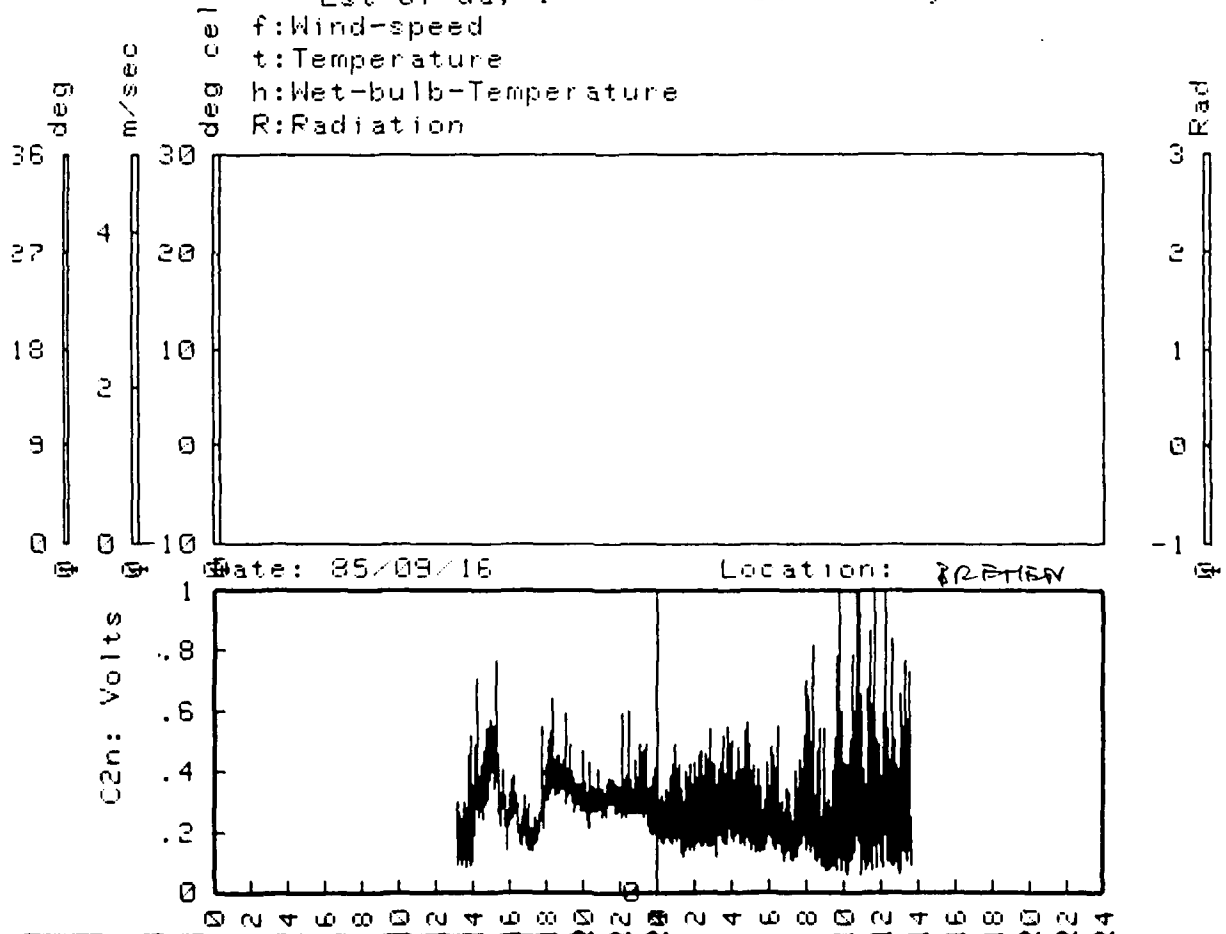
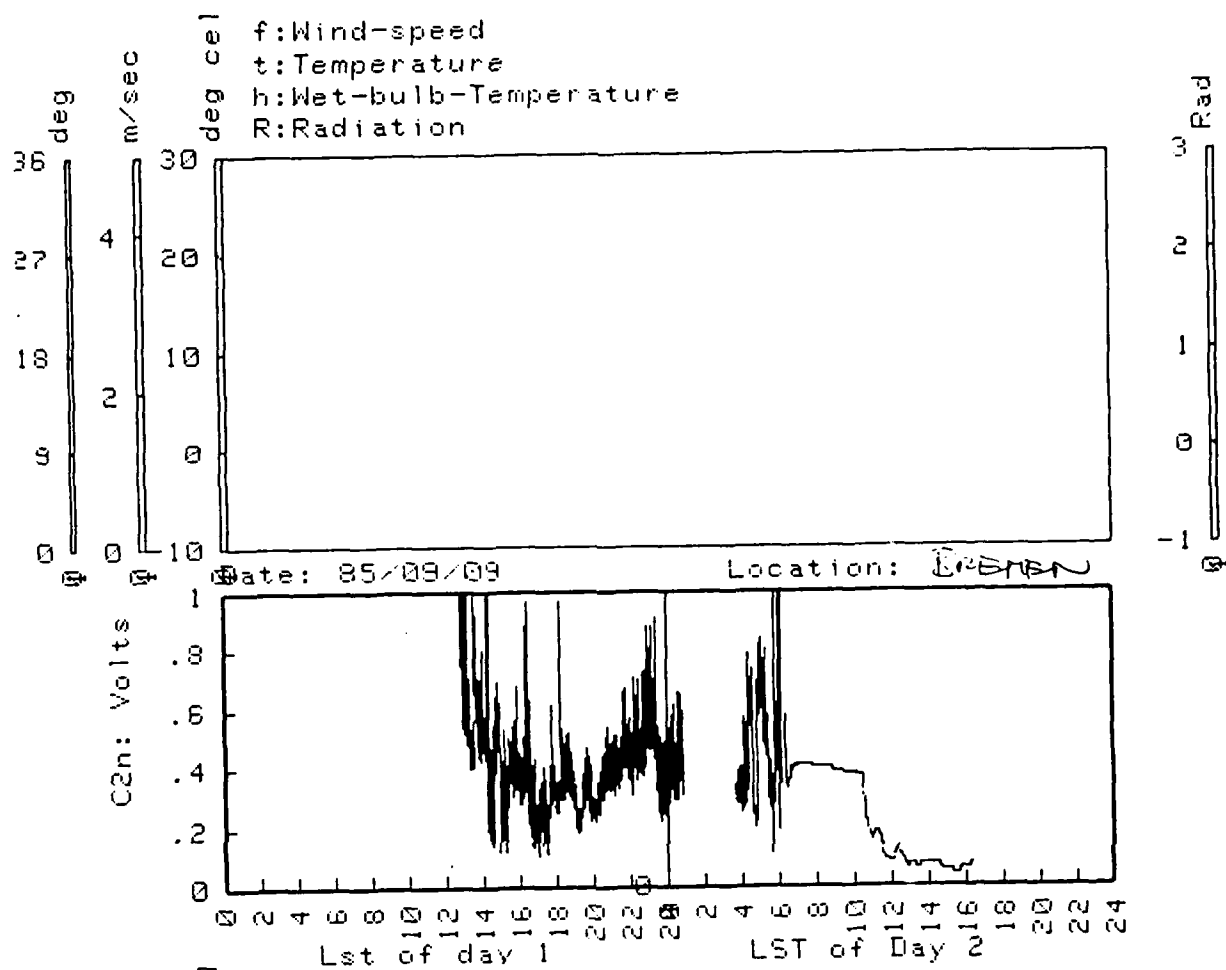


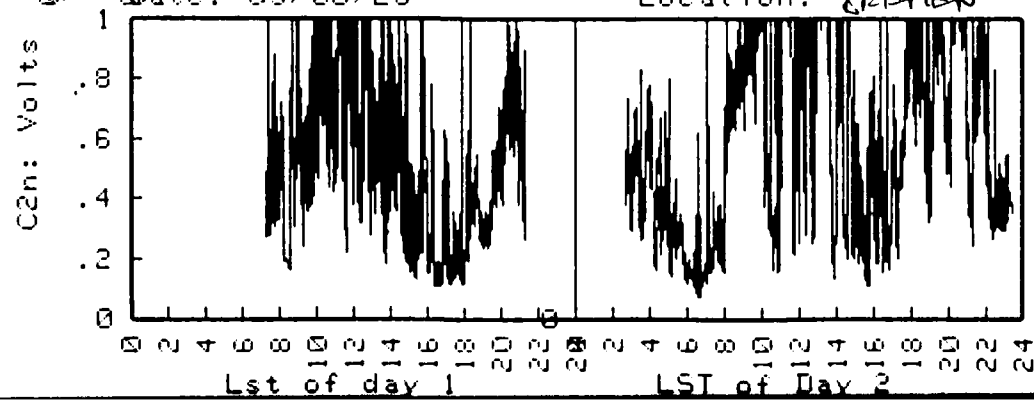
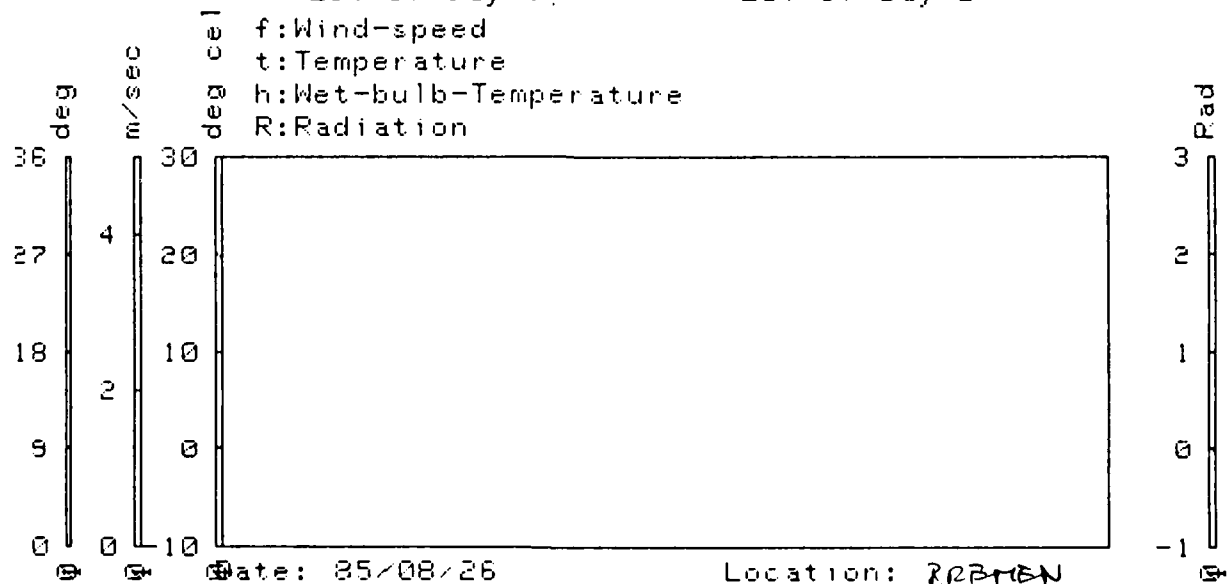
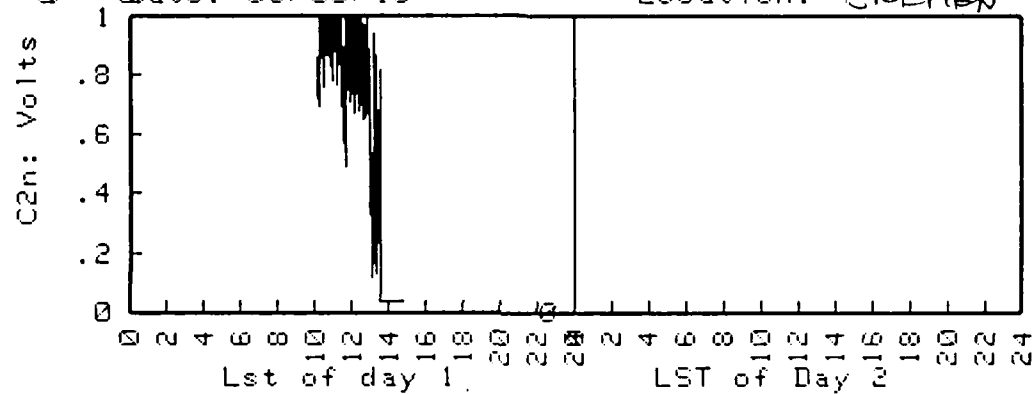
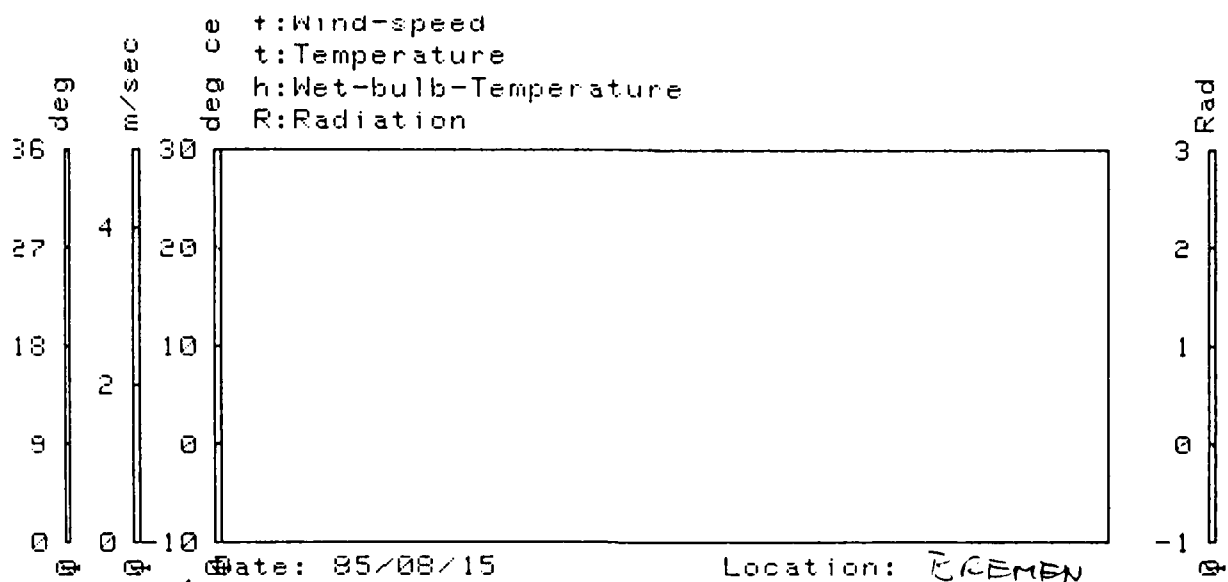


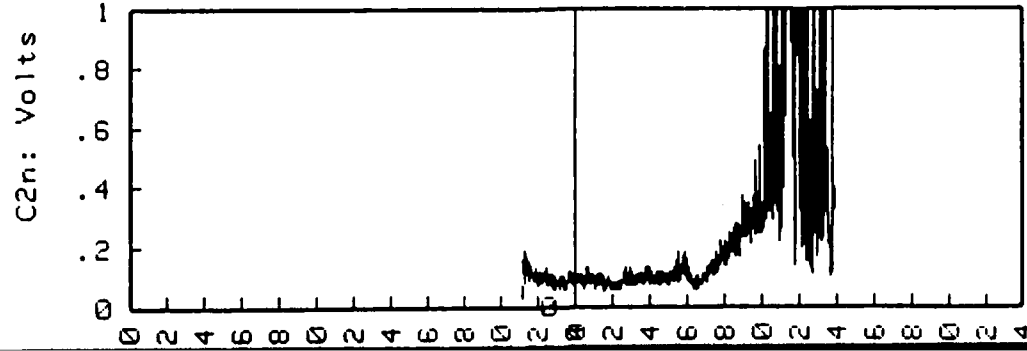
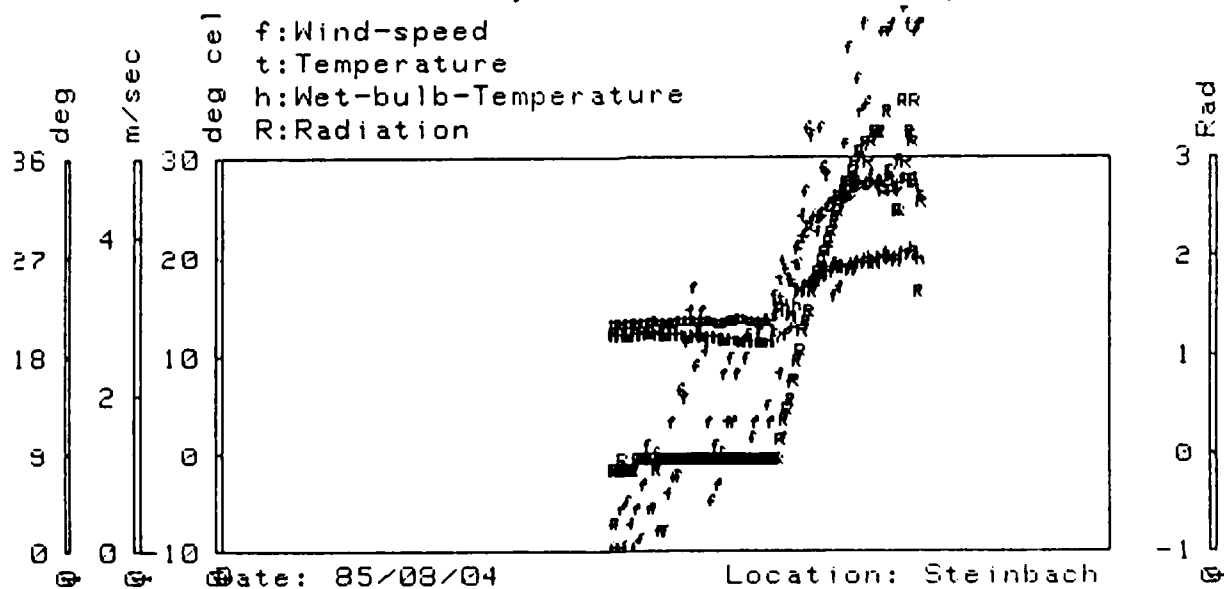
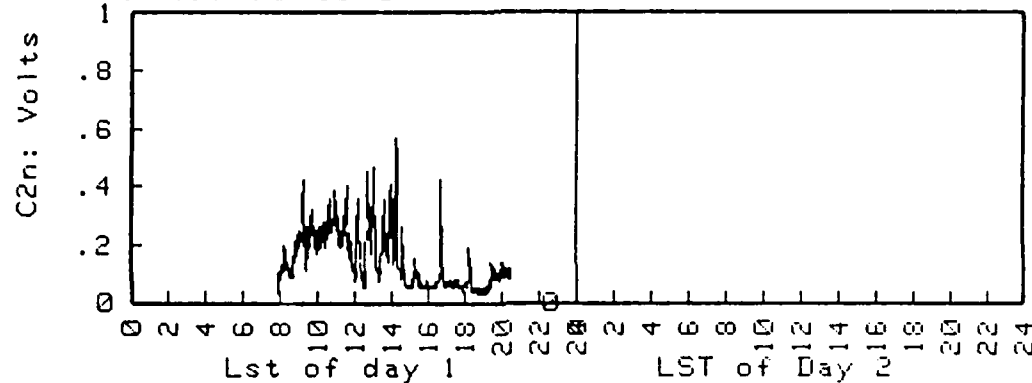
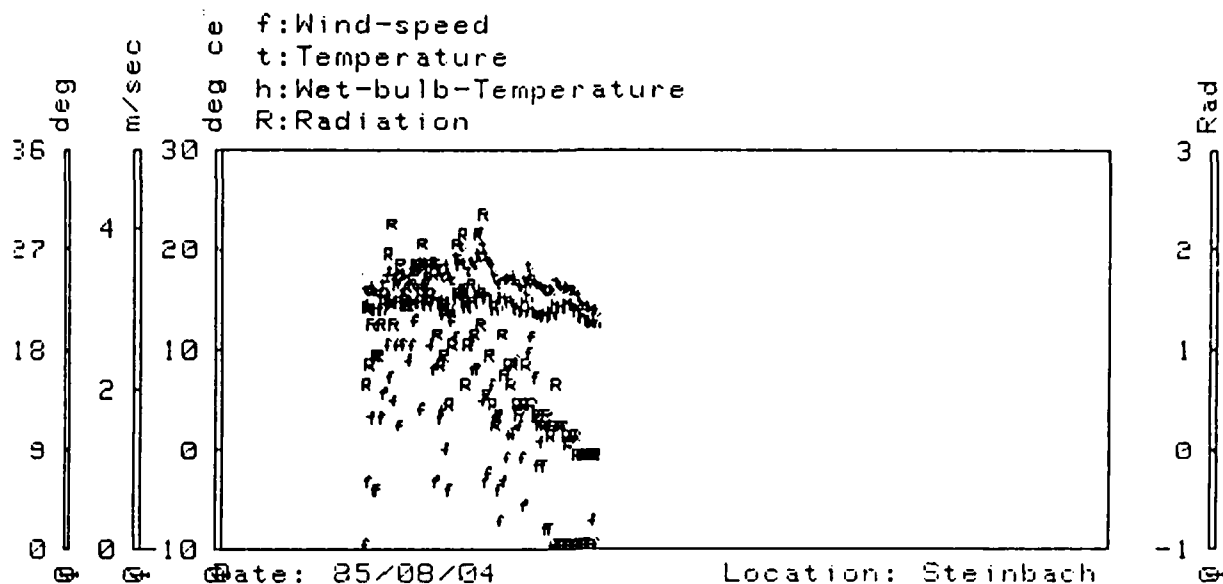












Figures:

Measurements of C2n (lower part) and meteorological parameters  
for STEINBACH

Measurements of C2n (lower part)  
for BREMEN

Mean temperature in Celsius in January (1931-1960)

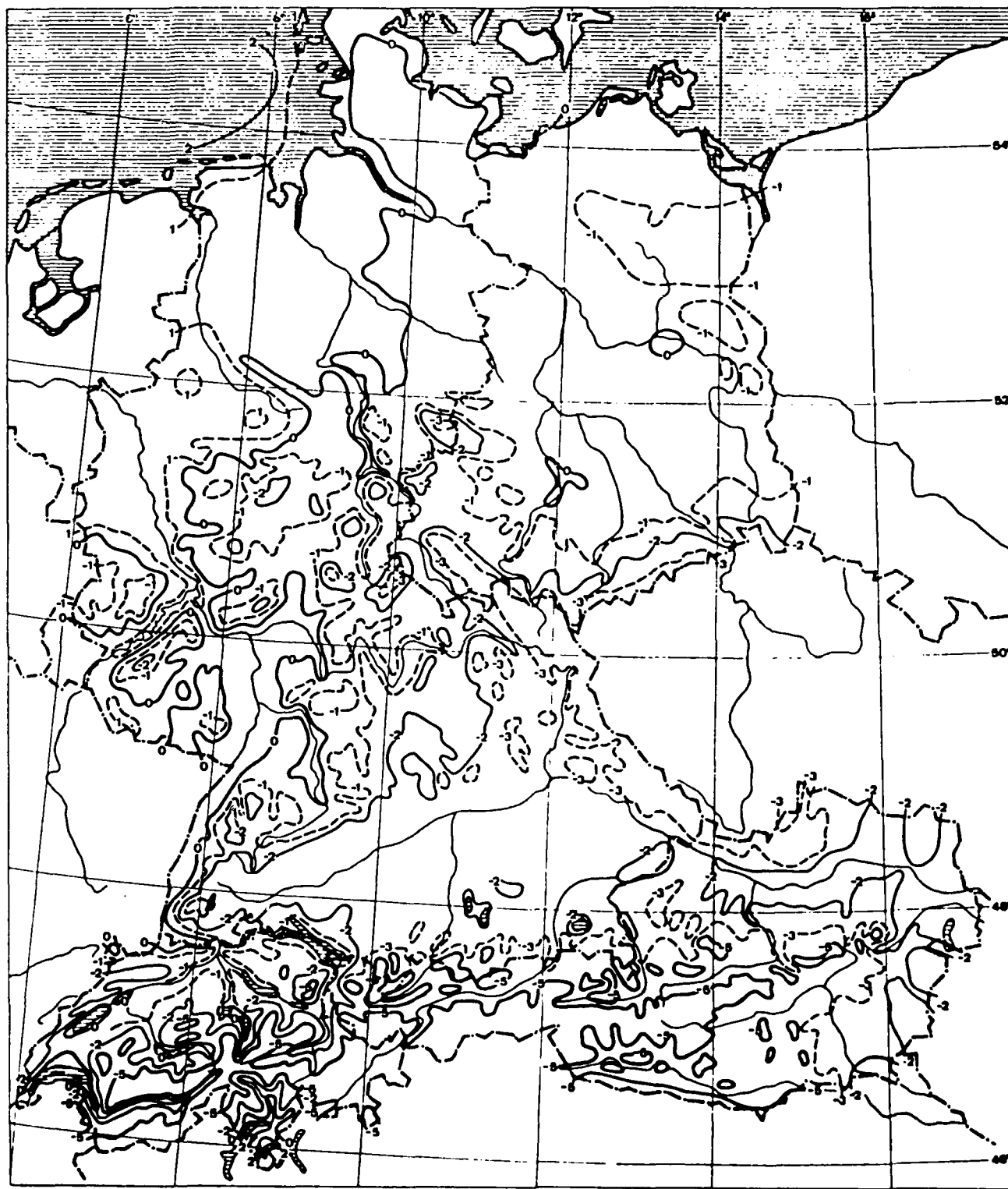


Fig.17. Mean temperature ( C) in January, 1931-1960.



Mean temperature in Celsius in July (1931-1960)

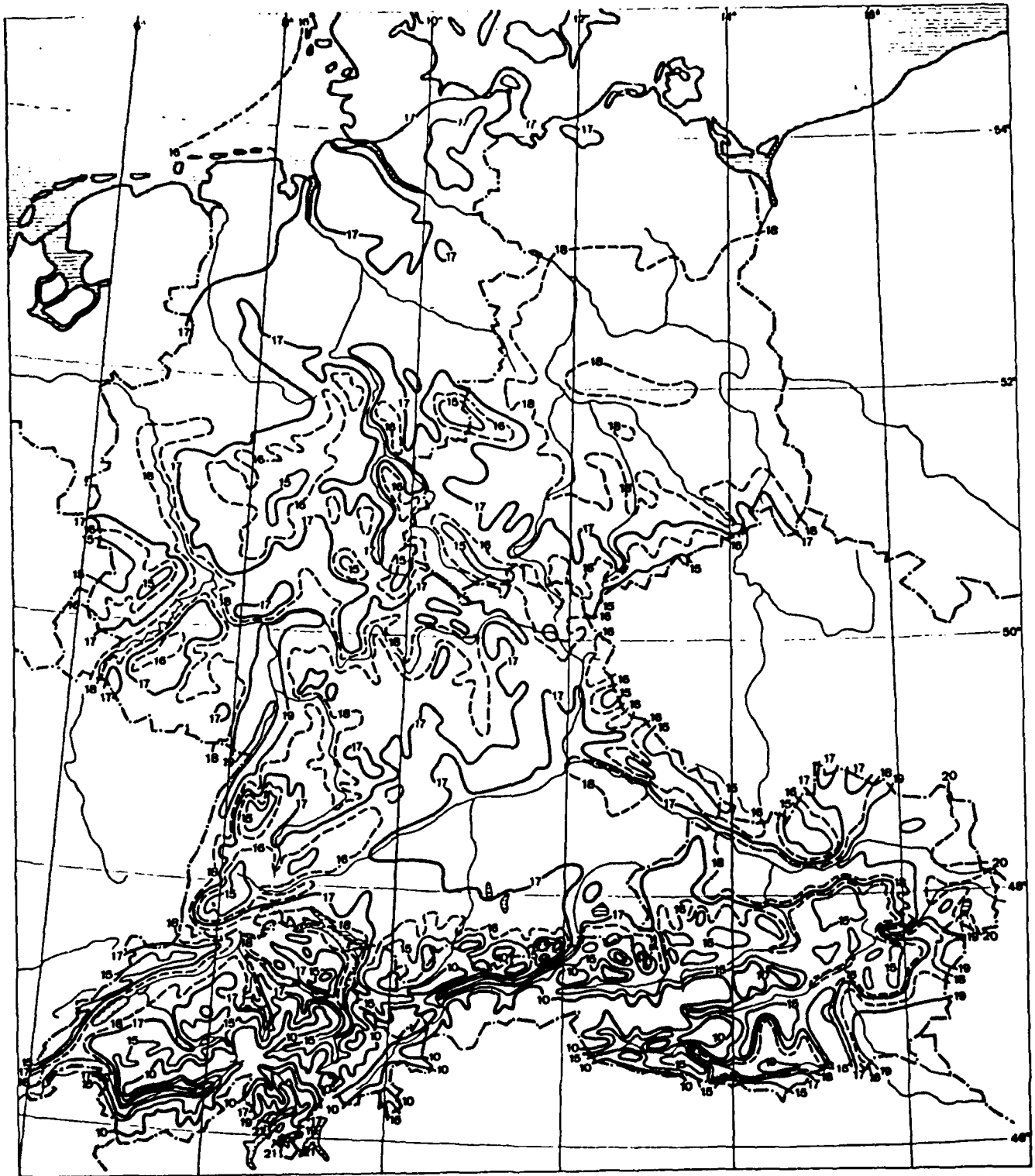
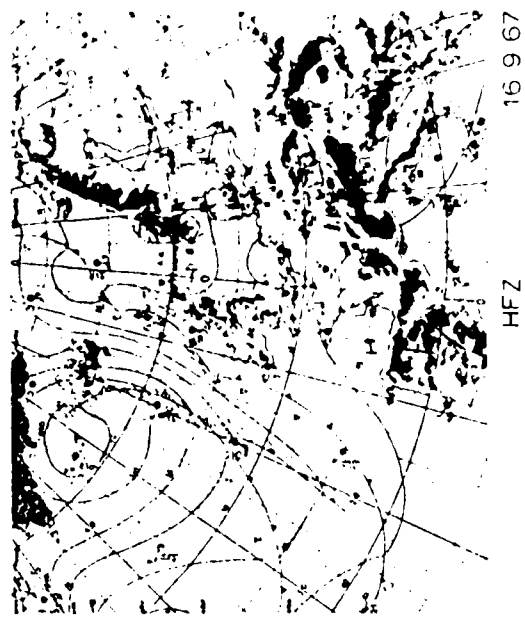
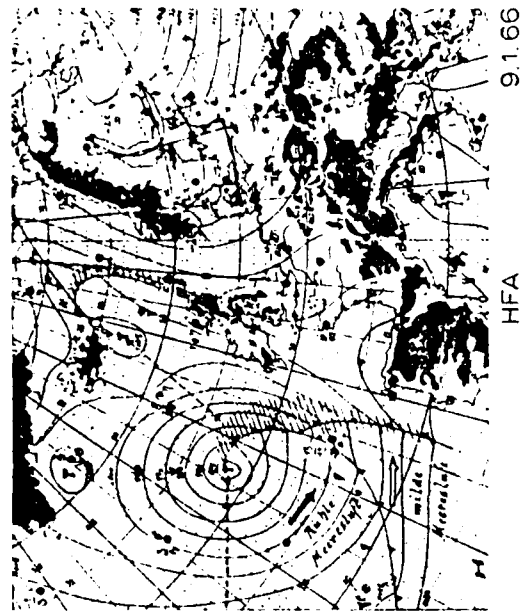
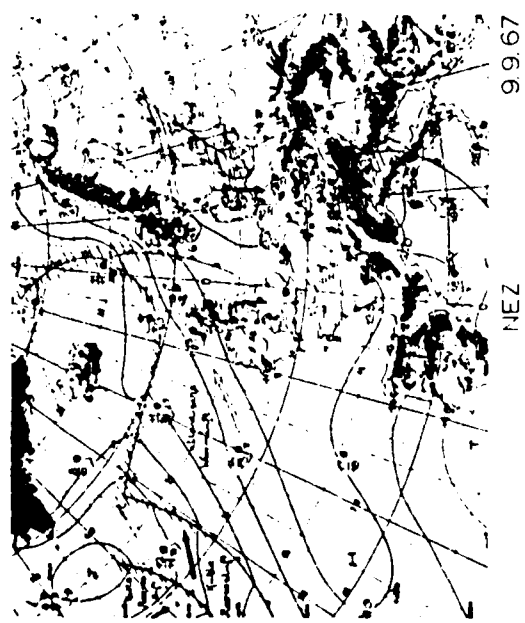
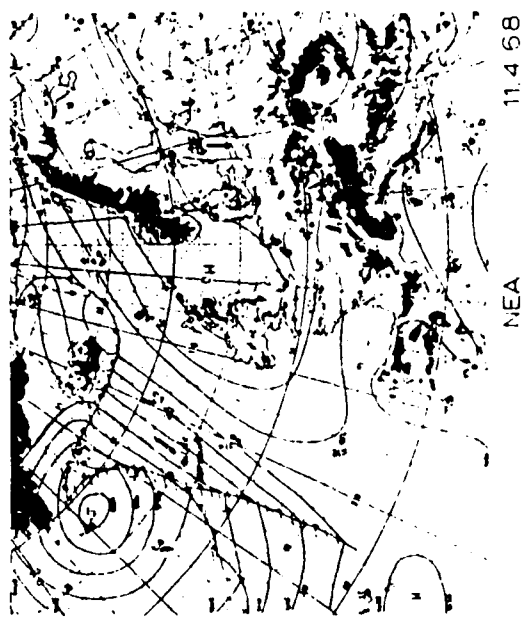
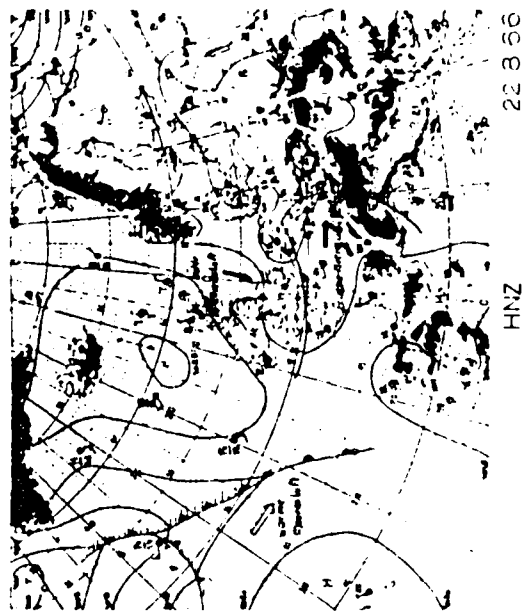
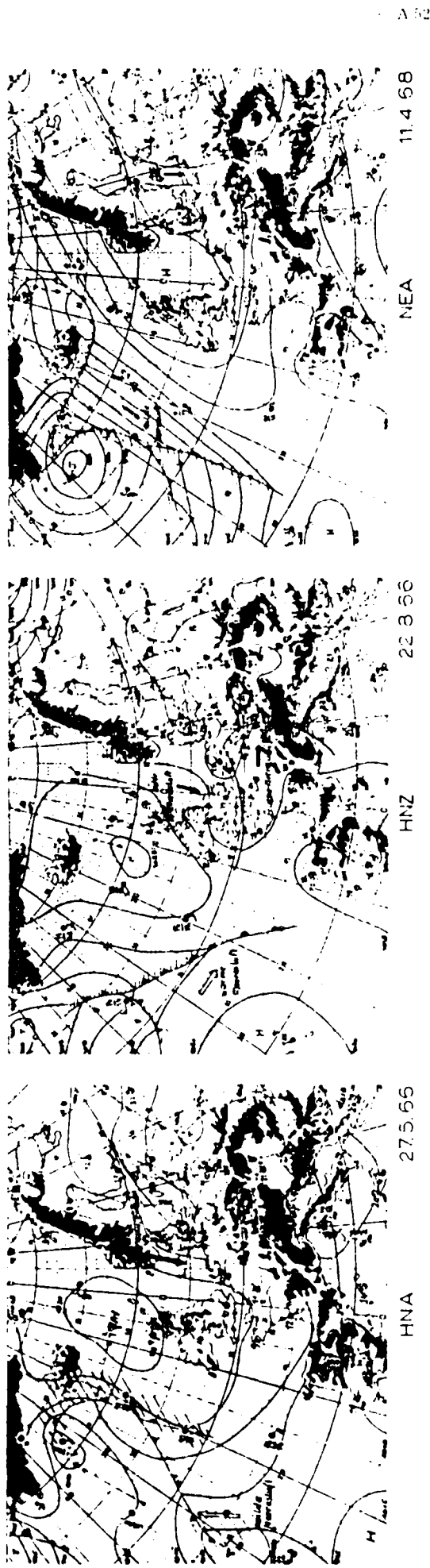
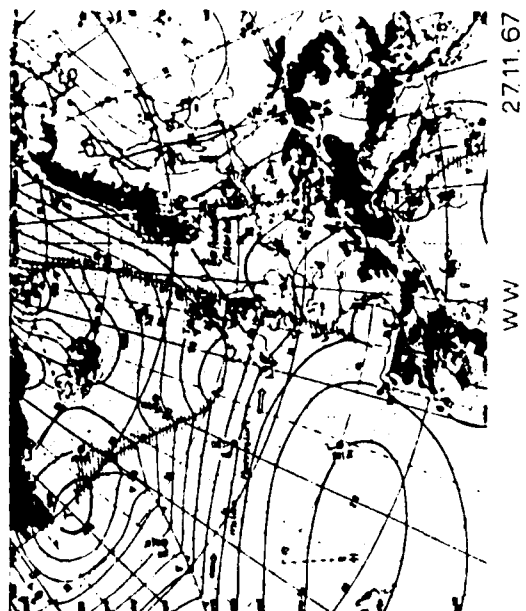
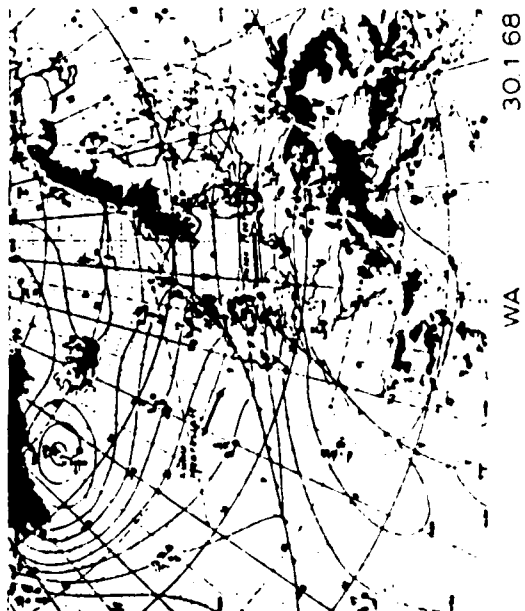
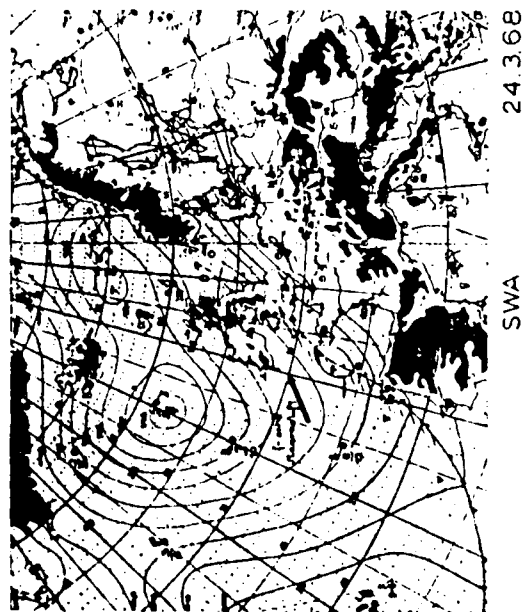
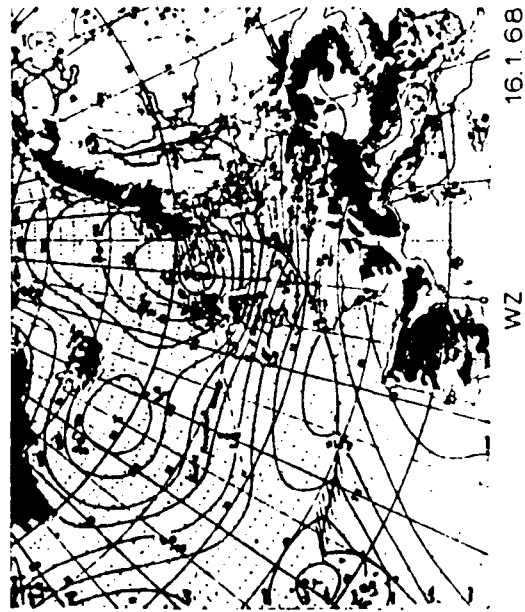
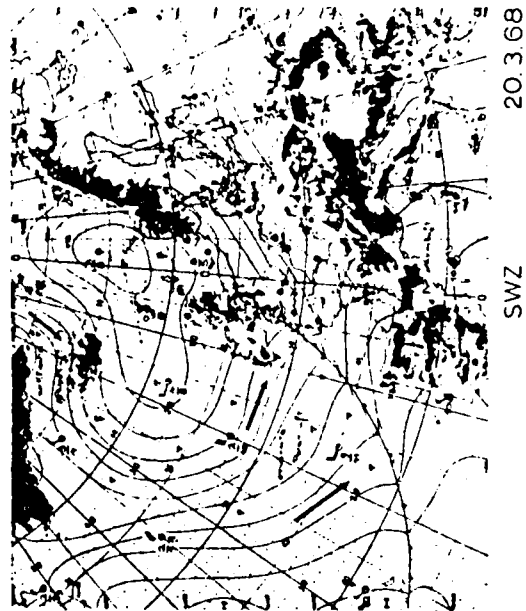
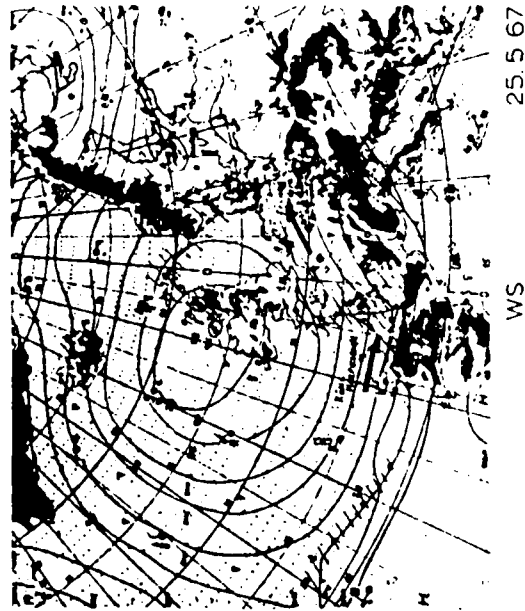


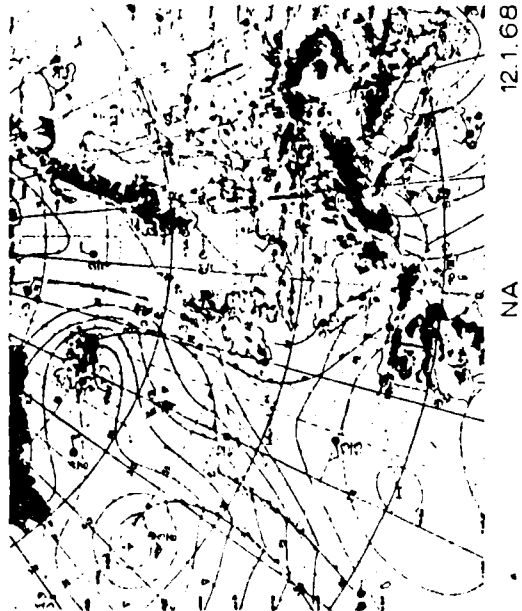
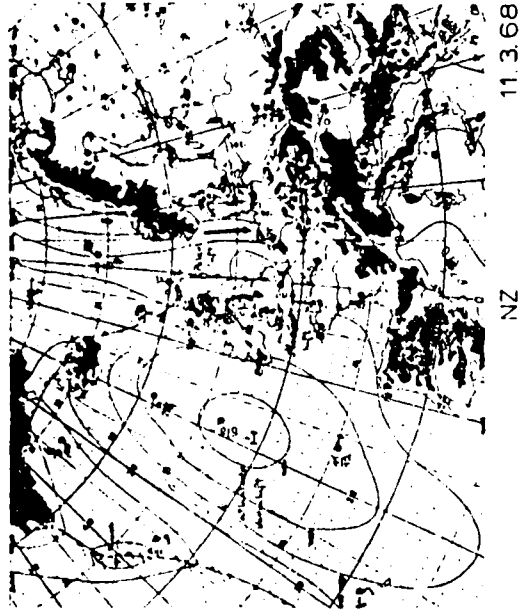
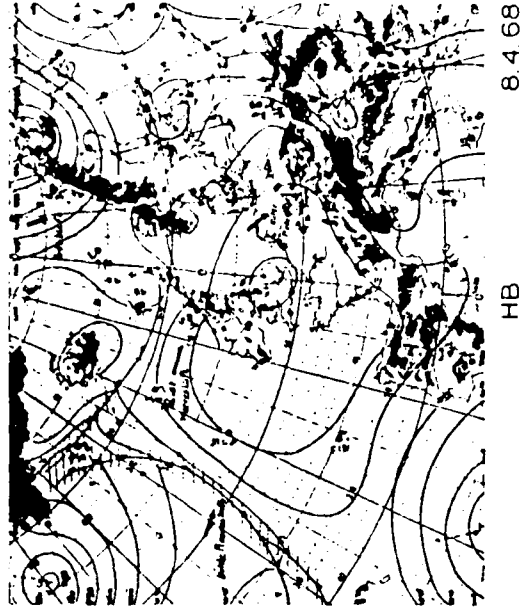
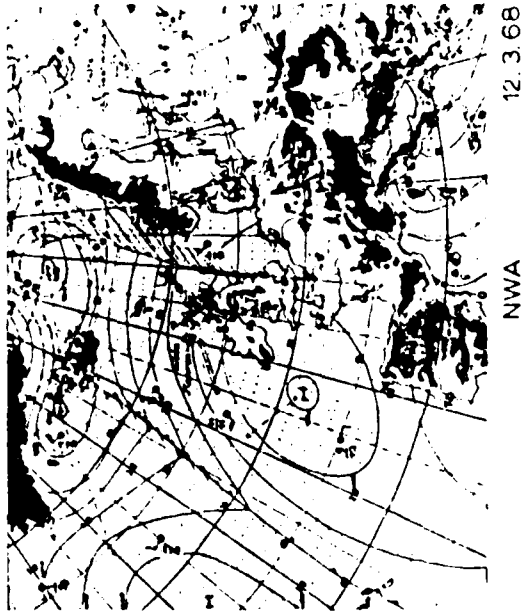
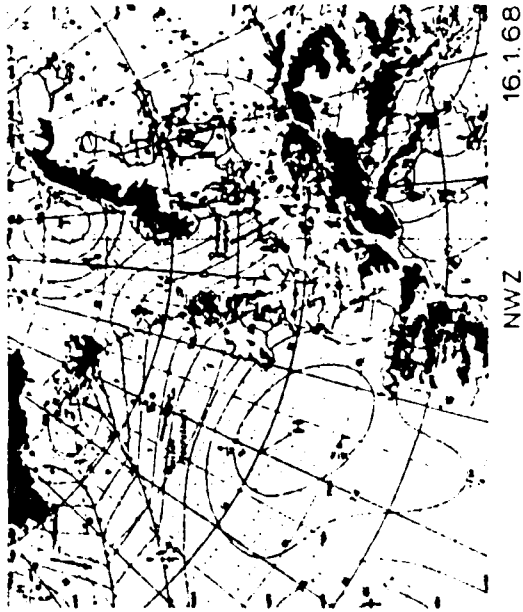
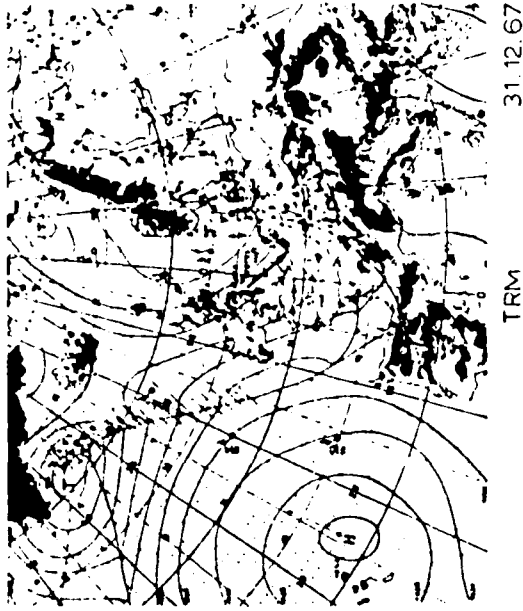
Fig.18. Mean temperature (°C) in July, 1931-1960.



7 Typical Examples of European Main-Weather-Types



5 Typical Examples of European Main-Weather-Typs



4 Typical Examples of European Main-Weather-Typs

# 3 DIE GROSSWETTERLAGEN EUROPAS D 6170 E

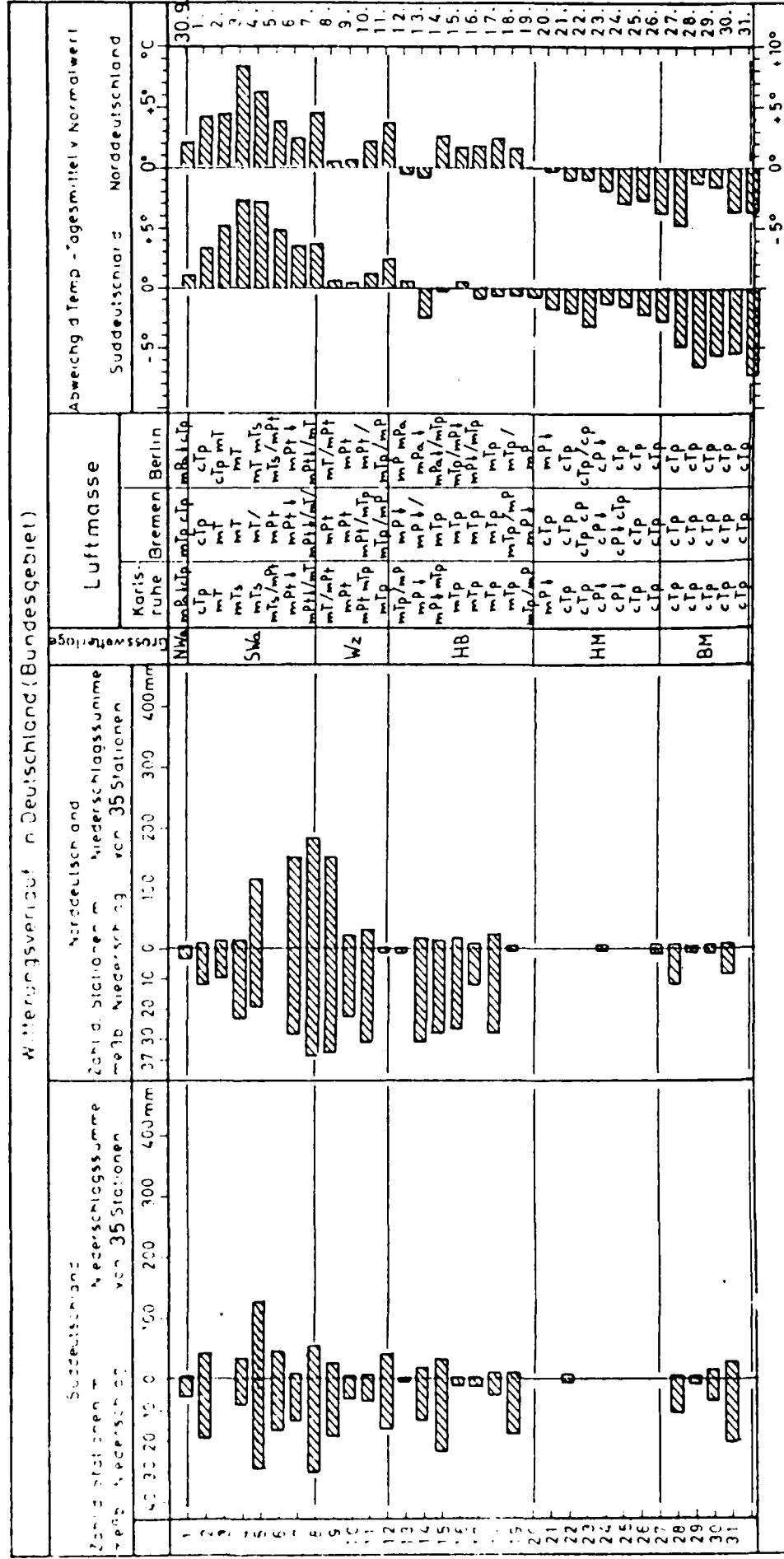
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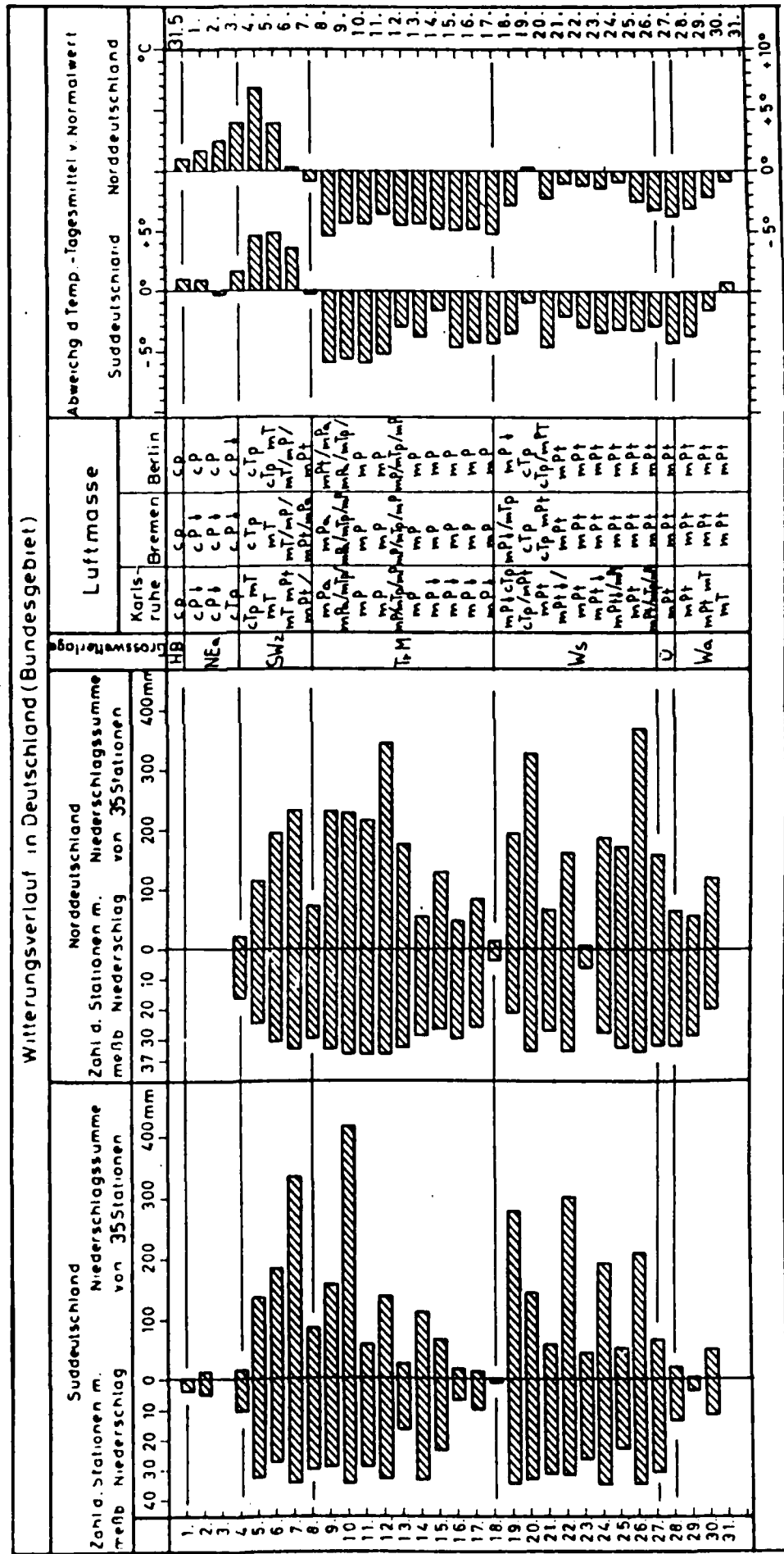
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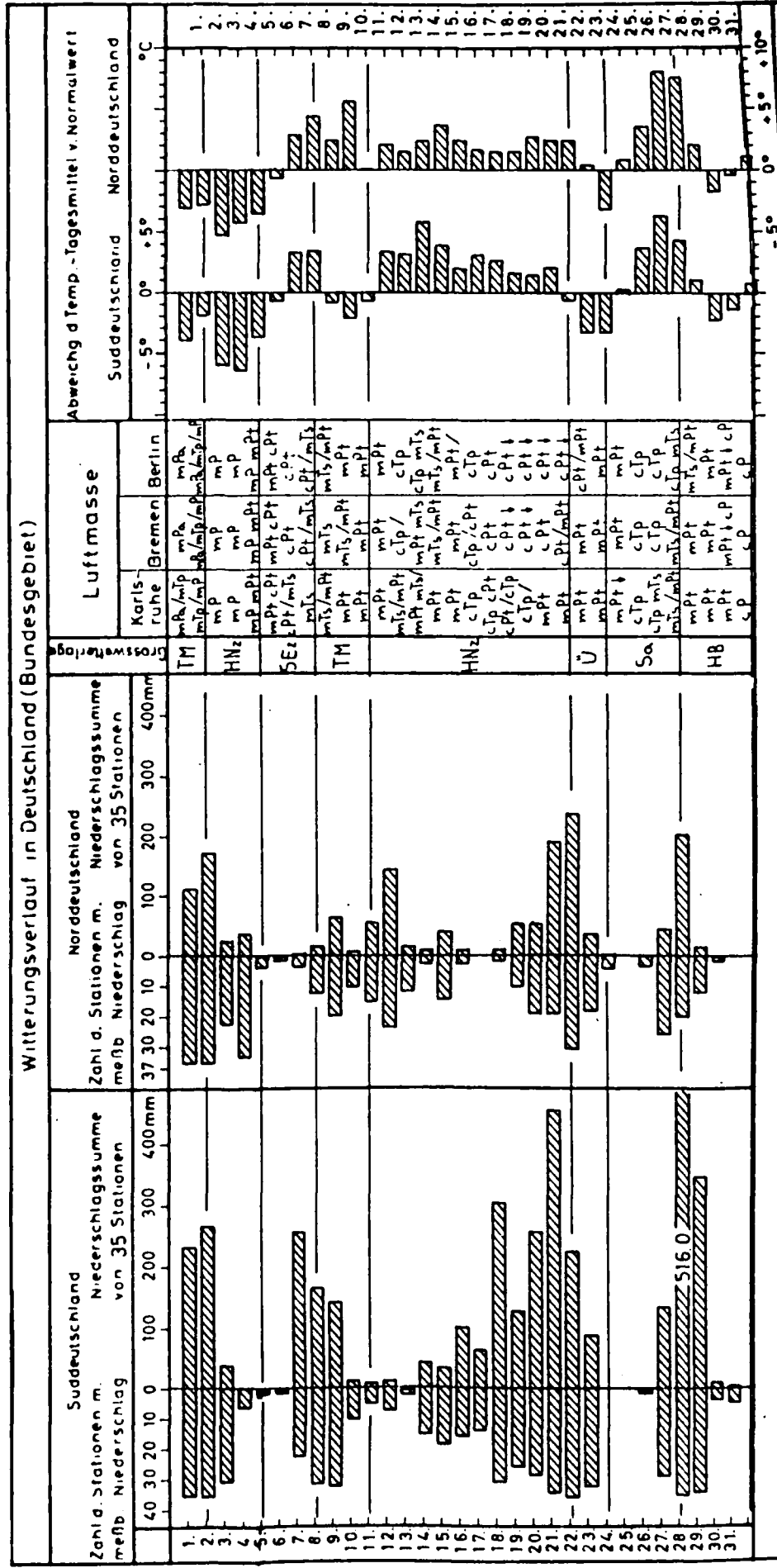
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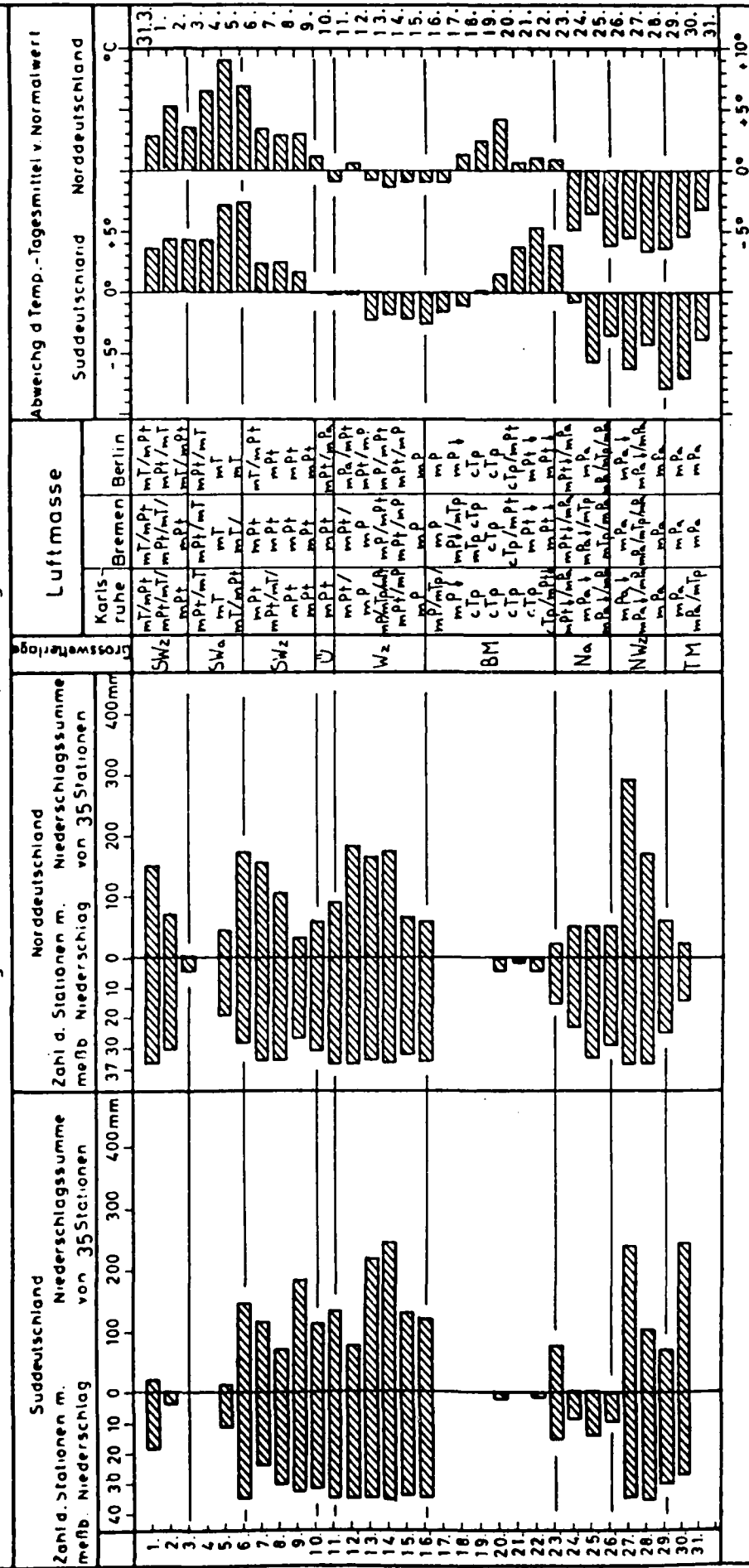
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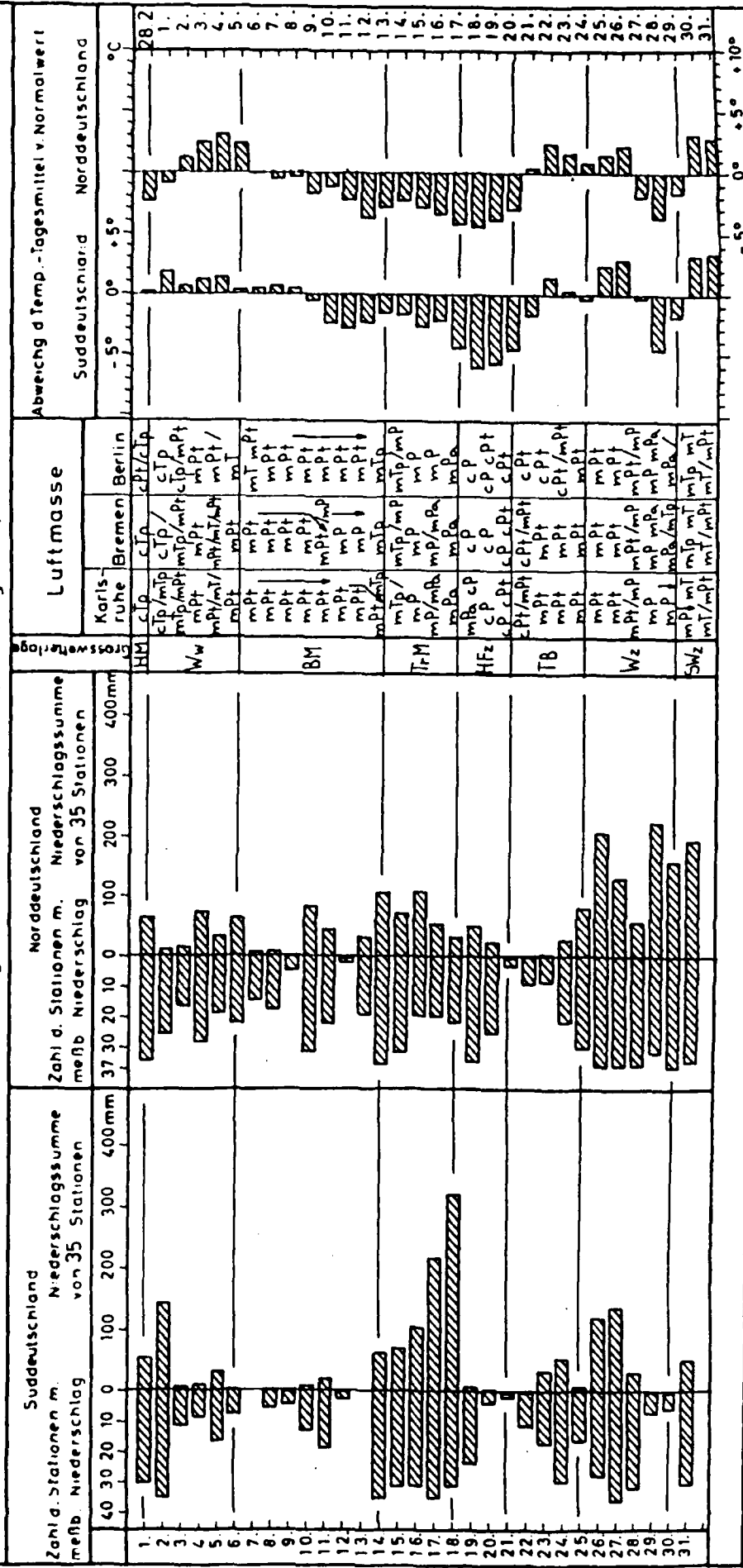
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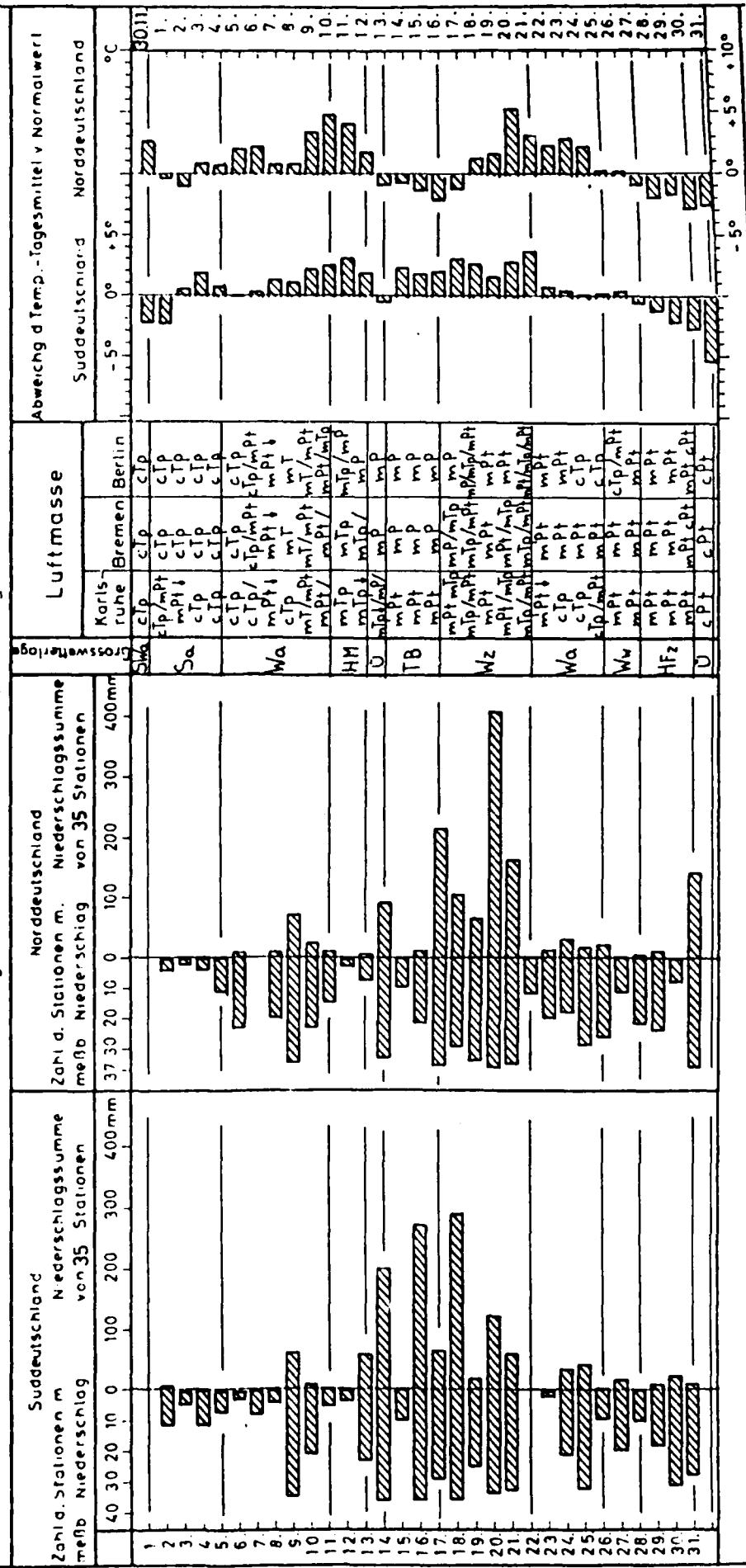
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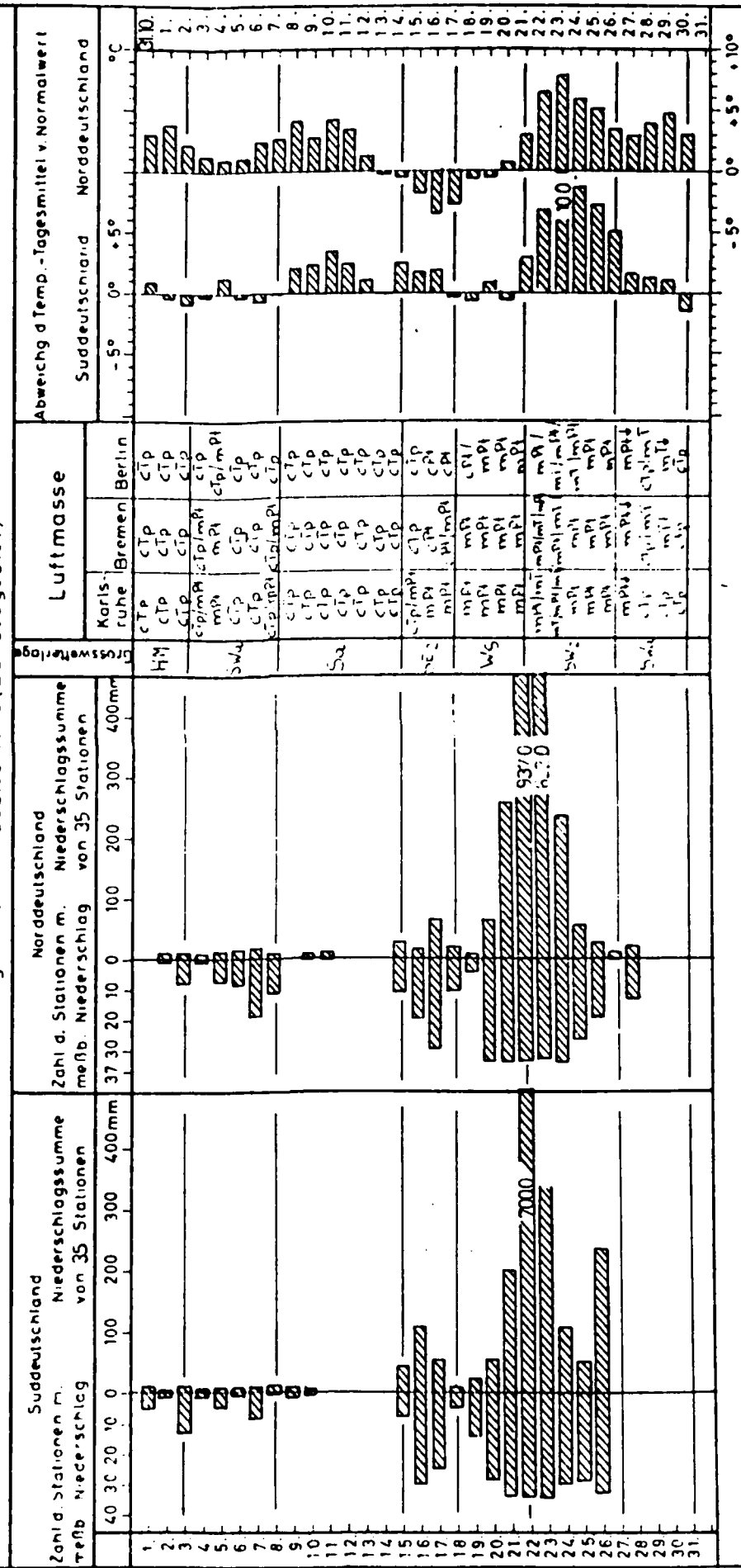
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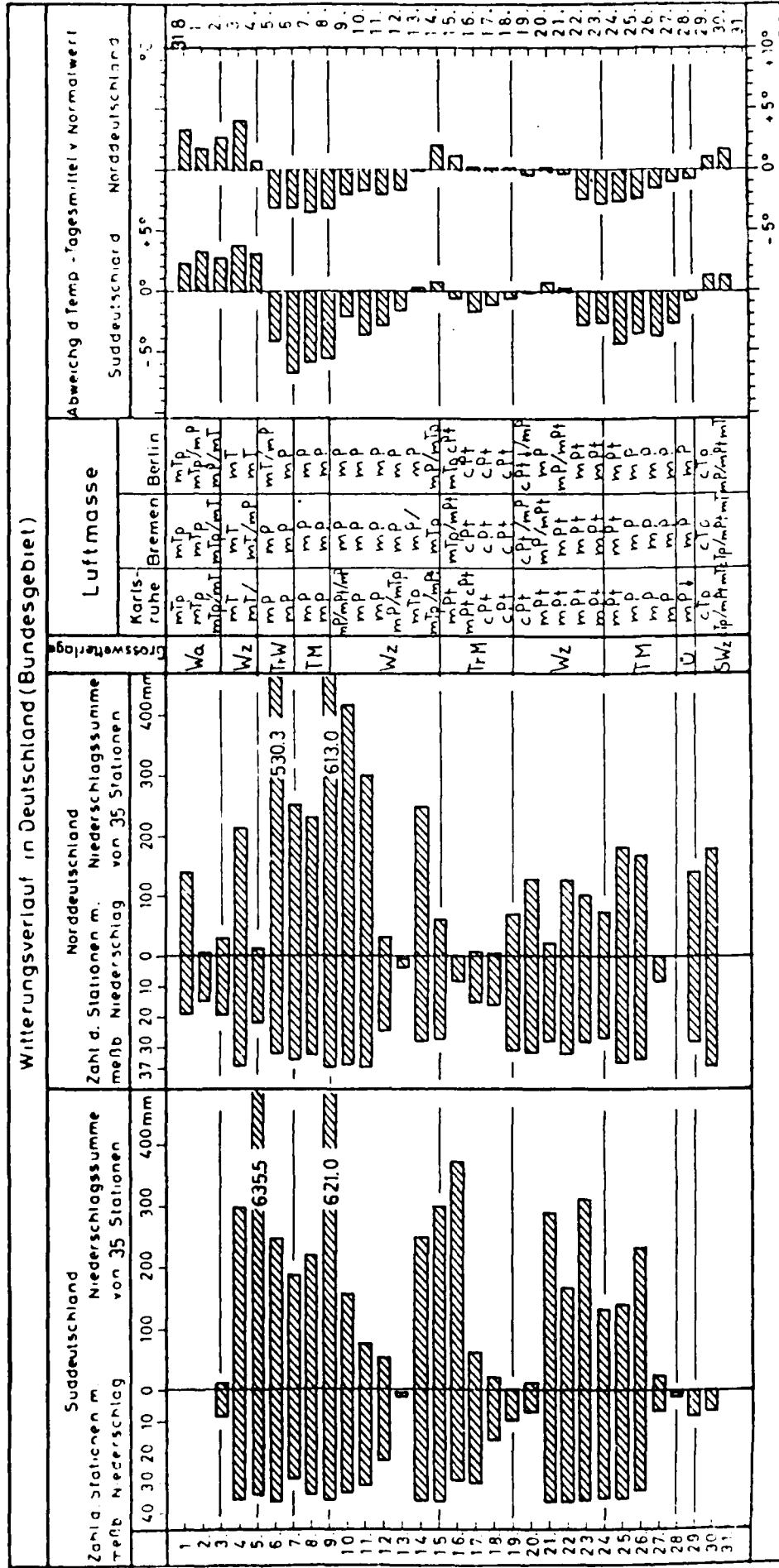
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Table(s) 3.

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and

Air-Mass (Luftmasse)      1. Karlsruhe: representative for STEINBACH

2. Bremen: representative for BREMEN

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